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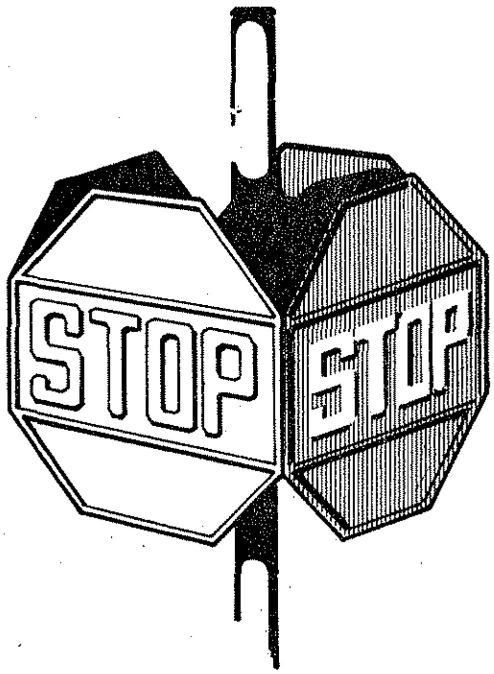
PORTABLE SCHOOL STOP SIGNS

AND OTHER NON-UNIFORM SCHOOL STOP CONTROL DEVICES



PROJECT HR-190 FINAL REPORT

PREPARED FOR

HIGHWAY DIVISION IOWA DEPARTMENT OF TRANSPORTATION

MAY 1978

ENGINEERING RESEARCH INSTITUTE
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REPORT FOR

HIGHWAY DIVISION

IOWA DEPARTMENT OF TRANSPORTATION

IOWA HIGHWAY RESEARCH BOARD

PROJECT HR-190

SUBMITTED BY

ENGINEERING RESEARCH INSTITUTE

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EXECUTIVE SUMMARY

Portable (roll-out) stop signs are used at school crossings in over 300 cities in Iowa. Their use conforms to the Code of Iowa, although it is not consistent with the provisions of the Manual on Uniform Traffic Control Devices adopted for nationwide application. A survey indicated that most users in Iowa believe that portable stop signs provide effective protection at school crossings, and favor their continued use.

Other non-uniform signs that fold or rotate to display a STOP message only during certain hours are used at school crossings in over 60 cities in Iowa. Their use does not conform to either the Code of Iowa or the Manual on Uniform Traffic Control Devices. Users of these devices also tend to favor their continued use.

A survey of other states indicated that use of temporary devices similar to those used in Iowa is not generally sanctioned. Some unsanctioned use apparently occurs in several states, however. A different type of portable stop sign for school crossings is authorized and widely used in one state. Portable stop signs similar to those used in Iowa are authorized in another state, although their use is quite limited.

A few reports in the literature reviewed for this research discussed the use of portable stop signs. The authors of these reports uniformly recommended against the use of portable or temporary traffic control devices. Various reasons for this recommendation were given, although data to support the recommendation were not offered.

As part of this research, field surveys were conducted at 54 locations in 33 communities where temporary stop control devices were in use at school crossings. Research personnel observed the obedience to stop control and measured the vehicular delay incurred. Stopped delay averaged 1.89 seconds/entering vehicle. Only 36.6 percent of the vehicles were observed to come to a complete stop at the study locations controlled by temporary stop control devices. However, this level of obedience does not differ from that observed at intersections controlled by permanent stop signs.

Accident experience was compiled for 76 intersections in 33 communities in Iowa where temporary stop signs were used and, for comparative purposes, at 76 comparable intersections having other forms of control or operating without stop control. There were no significant differences in accident experience between the study locations and the control locations, despite the higher pedestrian exposure at the designated school crossings using temporary stop signs.

An economic analysis of vehicle operating costs, delay costs, and other costs indicated that temporary stop control generated costs only about 12 percent as great as permanent stop control for a street having a school crossing. Midblock pedestian-actuated signals were shown to be cost effective in comparison with temporary stop signs under the conditions of use assumed. Such signals could be used effectively at a number of locations where temporary stop signs are being used.

The results of this research do not provide a basis for recommending that use of portable stop signs be prohibited. However, erratic patterns of use of these devices and inadequate designs suggest that improved standards for their use are needed. Accordingly, nine recommendations are presented to enhance the efficiency of vehicular flow at school crossings, without causing a decline in the level of pedestrian protection being afforded. These recommendations are as follows:

1. After a school crossing manual is prepared, the Code of Iowa should be revised to afford legal status to this manual and to correct inconsistencies relative to the use of temporary stop control devices at school crossings.
2. The Iowa Department of Transportation should prepare and disseminate a school crossing manual to assist local jusidictions in planning and implementing programs of school crossing protection.
3. Existing locations at which temporary school stop control are being used should be studied with a view toward either eliminating stop control or substituting a feasible and effective alternative form of control.
4. A standard design should be prepared for a roadside-type temporary school stop control device.
5. Portable (roll-out) stop signs should be located in advance of the crossings to be protected.

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I. INTRODUCTION

Background for the Study

Uniformity among traffic control devices is essential if drivers are to recognize a device nearly instantaneously and respond rapidly in the desired manner to its message. Instantaneous recognition and rapid response are functions of the placement of a device, in addition to its manner of use and design, including color, size, pattern, and other features. To achieve uniform usage, the Manual on Uniform Control Devices (MUTCD) has been prepared to afford guidance in the design and placement of traffic control devices. Adherence to the MUTCD may be expected to enhance the capability of a roadway to carry traffic expeditiously and safely.

Problems arise when local practices in the use of traffic control devices conflict with the MUTCD. Local persons may become familiar with a particular usage. However, those from outside the community may find a practice confusing or even contradictory when it is related to those with which they are familiar. This, in turn, gives rise to the possibility of erratic behavior with a concomitant adverse effect on traffic flow, and to the potential for accidents.

One such deviation from standard practice occurs commonly in Iowa, when various types of temporary stop signs are used to afford protection during certain time periods at school crossings. The most common type is a portable (roll-out) stop sign placed in the roadway. Less common, but also frequent in Iowa, is the use of other non-uniform stop signs placed at the side of the roadway. Those signs present a STOP message only temporarily, using a full sign that rotates or a changeable message sign that is hinged vertically or horizontally.

Use of the latter type of device does not have specific legal authority in Iowa. However, the use of portable signs is consistent with Section 321.249, Code of Iowa, which authorizes the use of "movable stop signs" placed in streets and highways to delimit school zones.

Section 321.252, Code of Iowa, directs the Department of Transportation to "adopt a manual and specifications for a uniform system of traffic-control devices......for use upon highways within this state." Specifications "for a uniform system of traffic-control devices in legally established school zones" are to be included in this manual. The MUTCD has been adopted for use in Iowa in response to this legislative mandate.

Section 7B-6 of the MUTCD provides that "Portable school signs shall not be placed within the roadway at any time." This official position was recently reiterated in the following comment made as part of a ruling by the Federal Highway Administrator in response to a request for changes in the MUTCD (in "Official Rulings on Requests for Interpretations, Changes, and Experimentations," Vol. V, June 1974, p. 13):

> Section 7B-6 of the MUTCD expressly prohibits portable school signs from being placed within the roadway at any time. The reason for this prohibition relates to the inherent dangers of vehicles striking the device or its support and being thrown out of control and of vehicles striking pedestrians who must place the device in the roadway and then remove it after school hours.

Hence, the provisions of the Code of Iowa and the state's manual on traffic control devices seem clearly to be inconsistent with each other. Because of the clear conflict with the MUTCD, the Federal Highway Administration is not able to approve recommendations for portable stop signs that are formulated through studies conducted under the Federal-Aid Highway Safety Program. This occurs despite the perceived advantages of the portable signs and their previous use in the study communities. Hence, the value of these safety-oriented studies is diminished.

Project Overview

Objectives

The objectives of this research were to determine the advantages and disadvantages of use of portable school stop signs and other non-uniform school stop control devices; to establish whether their advantages outweigh their disadvantages when compared with alternative forms of control; and to recommend the most appropriate controls for school crossings having different characteristics.

Research Plan

The conduct of this research involved the accomplishment of the following research tasks:

Task 1. Review of literature and previously accomplished research.

Task 2. Survey of current practices.

Task 3. Field surveys.

Task 4. Analysis of field survey data.

Task 5. Formulation of recommendations.

Task 6. Reports.

Tasks 1 through 5 are described and the results are summarized in Chapters II through VI of this report. Quarterly reports were submitted during the course of the research to describe progress and provide an interim reporting of research results.

in turn, lead to similar violations at other locations and may contribute to a general increase in accidents (4). He also considers the false sense of security afforded to child pedestrians, which results in accidents when conflicts occur with motorists who have learned to violate the regulation.

An earlier study by White also addressed the matter of portable stop signs (5). A conclusion resulting from this study is as follows:

> "From a motorist standpoint it was found that positive stops were not popular. This can better be appreciated when we recognize that the motorist was required to make unnecessary stops at periods of the day when school children were not in the process of going to or from school. The use of the signs was in many cases very poorly supervised. Frequently they were rolled into the street for extensive periods prior to the opening and closing of schools and during the entire noon hour period. A well recognized form of traffic regulation has been found to be one that is popular with the motorists. Out-of-town motorists were being apprehended, paying their fines and complaining about the lack of uniform regulations. The school children were beginning to build up an air of defiant confidence in the school stop signs. In many cases it was common to observe the school children walking into the street unmindful of the possible disobedience of the school sign on the part of the motorists."

It is clear from these opinions and the actions of the National Advisory Committee on Uniform Traffic Control Devices in recommending against their use that the general opinion among traffic authorities is one of strong opposition to the use of temporary stop control devices at school crossings.

Traffic Control Devices for Use in School Areas

Among the protective devices specified in the MUTCD for use at school crossings are warning signs (school advance and school crossing signs), school speed limit signs, crosswalk markings, and school area traffic signals. Recommended practices for the use of these devices have been formulated by the Institute of Traffic Engineers (6). Each of these devices has been the subject of detailed study.

Several studies have been concerned primarily with the effects of various speed control devices upon driver behavior while traversing a school zone (7, 8, 9, 10). These generally show that comparatively little speed reduction may be attributed to the presence of warning signs or speed limit signs. Flashing beacons enhance the effect of a warning or regulatory sign and tend to induce some reduction in speeds under certain circumstances. According to one study, drivers tended to slow down or stop more frequently when one of the following conditions existed (7):

1. The approach speed of the vehicle was low.
2. The crossing took place in a marked crosswalk.
3. There was a relatively long distance between the vehicle and the pedestrian's point of entry into the road.
4. A group of pedestrians, rather than an individual, attempted to cross.
5. The pedestrian did not look at the approaching vehicle.

The effects of marked crosswalks on pedestrian safety as reported in the literature do not indicate particular safety benefits from their use. Reiss found that neither drivers nor students rated crosswalks particularly high as a measure to increase safety (9). Herms reported results of a study that indicated that the frequency of pedestrian-vehicle accidents was approximately six times as high in marked crosswalks as in unmarked crossings (11). The pedestrian accident rate was only twice as high in marked crosswalks, however, after correcting for the number of potential vehicle-pedestrian conflicts. Lawton also concluded that marked crosswalks "serve a limited function" (12).

However, experience from three other countries (Denmark, Israel, and the United Kingdom), as reported by Katz et al., demonstrated that marked crosswalks were safer than unmarked crossings (7). A study of two locations in Israel also indicated that vehicles reduced speed more when crossing a marked crosswalk in the presence of pedestrians than when crossing an otherwise similar unmarked location.

School area traffic signals have been the subject of a number of investigations. According to Reiss, students generally perceive signalized locations as safe places to cross (9). The report from that study also pointed out that problems may arise due to the lack of understanding by children of the meaning of various signal indications.

The probability that a school child will actuate a pedestrian push button before crossing is a function of age, but usage was found in a study by Miller and Michael to be less than 50 percent when school crossing guards were not present (8). Virtually all children crossed with the proper signal display when a crossing guard actuated the signal. A study by Husk found that use of pedestrian push buttons was significant only by elementary school students, and concluded that the use of signalized school crossings for junior high and high school students was not warranted (13).

Relevant Traffic Parameters

This study was concerned with the evaluation of temporary stop control devices used at school crossings. Three widely used parameters for evaluating the efficiency of any technique for traffic control are (1) the extent to which a particular control may contribute to the occurrence of accidents; (2) the obedience to the control by drivers; and (3) the delay occasioned by obedience to the control. Each of these parameters has been investigated previously by a number of researchers. Some of the other studies most closely related to this research are briefly described below.

The pedestrian accident problem has been the subject of numerous research efforts (14, 15, 16, 17, 9). The general conclusion from these studies is that relatively few pedestrian accidents involve children making a trip to school. Most child pedestrian accidents occur in residential areas at non-intersection locations. The age group from 5 to 14 is over-represented in the frequency of occurrence of pedestrian traffic deaths and injuries.

Obedience to a stop sign has been studied by several researchers in many different locations (18, 19, 20, 21, 22, 23). The proportion of vehicles stopping at stop signs as reported from these studies varied widely, from values as low as 3 percent to more typical values of 25 to 40 percent. Only infrequently were more than 60 percent of the vehicles observed to come to a complete stop at a stop sign, according to these reports.

Delay at an intersection approach varies quite widely depending upon local conditions. This parameter is largely a function of the volume on the intersecting street and the critical lag acceptable by drivers stopped at the approach, according to Raff (24). A study by Vodrazka et al. developed an expression for total vehicular delay at four-way stop intersections that yields an average delay of about 7.4 seconds per vehicle for the volumes typical of intersections in Iowa that utilize temporary stop control (25). Research by Volk developed expressions for delay for various types of intersection control (26). Although the intersections included in Volk's study generally had substantially higher volume than is typical of those in Iowa controlled by temporary stop control devices, the following results are representative of the average delay per vehicle found at urban and suburban intersections:

- Two-way stop control, minor highway: 10 seconds/vehicle.
- Four-way stop control, both highways: 12 seconds/vehicle.
- Traffic actuated signal, both highways: 8 seconds/vehicle.
- Fixed-time signal, both highways: 10 seconds/vehicle.

II. LITERATURE REVIEW

Non-Uniform Temporary Stop Control Devices

A few research projects that relate to the use of temporary school stop control devices have been reported in the literature. At least two committees of the Institute of Traffic Engineers (now the Institute of Transportation Engineers) surveyed users of traffic control devices and found significant use of portable or temporary school stop signs. A study reported in 1965 found that 19 cities (all with over 50,000 population) of 119 reporting used portable stop signs (1). A similar study reported in 1967 that five cities and one urban county of 48 jurisdictions surveyed used "swivel" or "flip" stop signs for temporary stop control (2).

Other writers have expressed opinions concerning portable stop signs based on their experiences, and have stated reasons for recommending against their use. Sielski states his position as follows (3):

> "The effectiveness of any portable stop sign as pedestrian protection is very debatable, and the reliance on traffic observance of intermittent stop control has proved conclusively that it provides insufficient protection for school children."

He concludes with a recommendation that "the use of non-standard signs be abandoned."

Marks, in reaching a similar conclusion, points out that the use of non-standard devices tends to result in violations of a regulation that,

III. MAILED QUESTIONNAIRES

In order to determine the extent of current usage of temporary, non-uniform stop control devices at school crossings in Iowa, questionnaires were sent to each of the 955 cities in the state. Questionnaires were also sent to each county sheriff. Every other state was also contacted to determine whether temporary non-uniform stop control devices are used in states other than Iowa. All of the survey instruments are displayed in Appendix A.

Description of Questionnaires

Cities in Iowa

An initial questionnaire was sent to each incorporated city in Iowa. This questionnaire was directed to the city official considered most likely to be in a position to respond. In several cases, however, the questionnaire was returned from a school official rather than a municipal officer.

The purpose of this initial questionnaire was to determine whether either portable (roll-out) stop signs or other non-uniform stop control devices were in use or had been used in the respondent's community. The respondent was also asked to designate the appropriate individual to receive a follow-up questionnaire if an affirmative response regarding use of these devices was given.

Four different follow-up questionnaires were developed. These were mailed to those cities indicating current or past use of temporary stop control devices. These varied as follows, depending upon the response received:

- C1 for cities indicating current use of portable (roll-out) stop signs at school crossings.
- C2 for cities not currently using portable (roll-out) stop signs, but indicating that these had been used in the past.
- C3 for cities indicating current use of other non-uniform stop control devices at school crossings.
- C4 for cities not currently using other non-uniform types of stop control devices, but indicating that these had been used in the past.

Some cities reported current use of one type of device and past use of another, or either current or past use of both types; they therefore received two follow-up questionnaires.

County Sheriffs

There were two purposes for sending questionnaires to county sheriffs in Iowa. First, they were asked to indicate those cities in their county using temporary stop control devices, and second, they were asked whether such devices were in use in rural areas in the counties. If a sheriff's response indicated use of either portable (roll-out) stop signs or other non-uniform stop control devices within a city, and if no response to an initial questionnaire had been received from that city, the city received the appropriate follow-up questionnaire C1 or C3.

Other States

The questionnaire sent to other states was very brief. It was directed to the person in charge of the traffic engineering function in the state highway or transportation department. It merely asked whether non-uniform types of stop control devices were being used in their states and invited comments. A letter or supplemental questionnaire was then individually structured as a follow-up to each state responding affirmatively.

Questionnaire Responses

Cities in Iowa

Of 955 cities in Iowa, 681 (71.3 percent) of the initial questionnaires were returned. The following is a summary of the numbers of responses:

• Currently using portable signs only.	204
• Currently using both portable signs and other non-uniform stop control devices.	28
• Currently using portable signs; had used other non-uniform stop control devices.	3
• Currently using other non-uniform stop control devices only.	6
• Currently using other non-uniform stop control devices; had used portable signs.	14
• Discontinued use of portable signs.	47
• Discontinued use of other non-uniform stop control devices.	3

• Discontinued use of both types of devices.	8
• Blank or unusable return.	3
• Use neither type of device and no past usage.	365
• Not returned.	274
Total	955

Many of the cities reporting no use or having discontinued use indicated that no school was located in those communities.

In addition to the cities responding affirmatively to the first questionnaire, other cities were described by sheriffs as using either portable stop signs or other non-uniform stop control devices at school crossings. Using information received from both sources, follow-up questionnaires were sent as follows:

- C1 - 312 sent (including 34 that also received another questionnaire), 239 returned (76.6 percent).
- C2 - 70 sent (including 21 that also received another questionnaire), 53 returned (75.7 percent).
- C3 - 57 sent (including 43 that also received another questionnaire), 37 returned (64.9 percent).
- C4 - 15 sent (including 12 that also received another questionnaire), 10 returned (66.7 percent).

The total returned was 339 (74.7 percent) of 454 follow-up questionnaires sent. Responses to these questionnaires are summaried in Appendix B.

Combining responses from Questionnaires C1 and C3, the frequency and duration of usage of temporary school stop control devices is shown in Table 1. The average number of times effectuated was 2.23/day.

Table 1. Frequency and duration of use of temporary school stop control devices

Number of uses/day	Number of cities	Average duration, hr
1	46	7.61
2	101	1.68
3	98	2.88
4	3	1.44
Not reported, indeterminate	28	--
Total or average	276	3.25

County Sheriffs

Responses were received from 87 (87.9 percent) of the 99 county sheriffs in Iowa. These responses indicated use of some type of temporary school stop control device in rural areas in three counties.

When responses to this questionnaire were used to supplement responses from the initial questionnaire directed to cities in Iowa, information on total usage of temporary stop control devices was available for 914 cities. These data are summaried in Table 2.

Table 2. Reported use of temporary school stop control devices

Usage		Number of cities	Percent of total reporting
Use portable (roll-out) signs	315		
Portable only		281	30.7
Portable and other types		34	3.7

Table 2. (Continued)

Usage	Number of cities		Percent of total reporting
Use other types of signs	64		
Other types only	30		3.3
Portable and other types	(34)	(incl. above)	(3.7)
No use of temporary stop signs	569		62.3
Not reported	41		--
Total	955		100.0

Other States

Responses were received from 48 (98.0 percent) of 49 states other than Iowa. Further communication was effected with six states as a follow-up to these responses.

Only two other states reported legal authority for the use of portable stop signs of the general type used in Iowa. Their use is permitted under Wisconsin statutes and similar signs are used in a very few cities. The signs used in Arizona in accordance with that state's legal authority for portable stop signs are substantially different, however. These portable signs are placed in the roadway and have a black legend on a white background. They bear the message STOP WHEN CHILDREN IN CROSSWALK. Normal usage is in combination with another portable sign that prohibits passing and sets forth a 15-mph speed limit in a school zone. These portable signs reportedly are used extensively throughout the state.

Eight other states reported some local unauthorized use of portable stop signs in school zones. Most of these states indicated that such use was not legal. One state official commented that his state did not want a variable stop condition on highways because it was believed that such a condition would lead to an increase in accidents and that such a sign, if struck, would endanger school children by becoming a flying projectile. Another state reportedly had used roll-out speed limit signs in school zones, but discontinued their use when a pedestrian was struck and hurt while putting a sign in place.

IV. FIELD SURVEYS

Field surveys were undertaken in order to determine the conditions accompanying use of temporary stop control devices in Iowa. Research personnel observed the flow of vehicular and pedestrian traffic at a representative sample of school crossings where either portable (roll-out) stop signs or other non-uniform school stop control devices were being used. These observations took place during the periods of use that could be expected to coincide with peak periods of school trip travel.

Data regarding vehicle speeds were obtained at some of the same locations during periods when the temporary stop was not in effect in order to determine free-flow speeds at these crossings. Additional locations were selected at which accident data could be obtained, in order to expand the sample size relating to accident experience at crossings using temporary school stop control devices.

Selection of Sample

A representative sample of locations for field surveys was selected for both portable (roll-out) stop signs and other non-uniform school stop control devices. Specific locations were selected for both types of devices to satisfy two criteria. First, the number of locations surveyed was to be proportional to the total usage of that device by population of city. For this purpose, the responses to the mailed questionnaires were used to determine usage. Six city-size categories were established with populations as follows:

1. Not more than 999.
2. At least 1,000 but not more than 2,499.
3. At least 2,500 but not more than 4,999.
4. At least 5,000 but not more than 9,999.
5. At least 10,000 but not more than 49,999.
6. At least 50,000.

Second, the locations were to be dispersed geographically. Geographical dispersion was assured by requiring that at least eight locations in at least five cities be selected from each of the six Iowa Department of Transportation districts.

Each location was visited prior to field survey work to assure its suitability for study. In all, 235 locations where temporary school stop devices were in use were investigated, and reconnaissance visits were made to 56 cities to select a sample for field surveys.

Field surveys were conducted at 54 locations, 28 of which were crossings using portable (roll-out) stop signs, and 26 of which used other non-uniform school stop control devices. These were located in 33 communities. All of the field survey locations are identified in Appendix C.

Of the 54 surveys, 25 were conducted in the morning period during which children were traveling to school, 28 covered an afternoon period of travel from school to home, and 1 was conducted during a midday period when both types of travel occurred. The period of observation was planned to coincide with the period during which the temporary stop control was in effect. However, because of irregularities in the times that these devices were put into use, this did not always prove to be the case. Some portable signs were left in place overnight or installed early, so that observers were not always at the location at the time the device was put in place or effectuated. Observation continued until the device was removed or rendered ineffectual, unless it were left in place continuously for a prolonged period. In the latter case, observation was terminated when it became evident that pedestrian flow had ended for that period of use. The average period of observation was 38 minutes, ranging from 4 minutes to 145 minutes.

An effort was made initially to use video tape equipment for field surveys. Data were gathered by this means at two locations. However, a suitable vantage point for mounting the camera was generally not available. Consequently, the remaining locations were surveyed by manual methods. Observers using stop watches and counting boards were located as inconspicuously as possible to collect data regarding vehicle obedience and delays, and to count vehicular and pedestrian volumes. Data obtained in the field were stored temporarily on voice recorders. General observations concerning a location were also recorded using the form displayed in Appendix D.

Obedience to Stop Control

Observers at each field survey location noted those motorists who observed the legal requirements of a stop sign by bringing their vehicles to a complete stop. A complete stop is attained when vehicle wheels cease to rotate, at least instantaneously. Vehicles that did not stop were noted in one of two other categories, those that "rolled through" and those that "did not slow." A vehicle was categorized as "rolled through" if it slowed perceptibly but did not achieve a complete stop. A vehicle that did not perceptibly reduce speed was categorized as "did not slow." The percentage of vehicles in each category at each survey location is indicated in Table 3.

Table 3. Observed obedience to temporary school stop control

Location number	Percent of vehicles		
	Stopped	Rolled through	Did not slow
1-1	92.4	7.6	0.0
2-1	12.6	86.2	1.1
2-2	17.0	83.0	0.0
3-1	31.2	64.1	4.7
4-1	17.9	69.6	12.5
5-1	29.0	70.3	0.7
6-1	14.7	83.6	1.7
6-2	5.5	85.9	8.6
7-1	21.4	75.0	3.6
7-2	30.8	65.4	3.8
8-1	26.2	73.8	0.0
9-1	54.9	44.1	1.0
9-2	92.7	7.3	0.0
10-1	10.0	90.0	0.0
11-1	64.4	30.8	4.8

Table 3. (Continued)

Location number	Percent of vehicles		
	Stopped	Rolled through	Did not slow
12-1	72.1	27.9	0.0
12-2	100.0	0.0	0.0
13-1	23.5	76.5	0.0
13-2	13.2	83.5	3.3
14-1	65.6	28.1	6.3
15-1	66.7	32.3	1.1
16-1	53.3	46.7	0.0
16-2	25.7	74.3	0.0
16-3	91.7	6.3	2.1
17-1	18.2	81.8	0.0
18-1	20.0	77.1	2.9
18-2	22.0	69.5	8.5
19-1	14.5	84.9	0.7
20-1	9.2	90.2	0.6
20-2	9.4	89.9	0.7
21-1	22.6	75.5	1.9
22-1	18.7	79.3	2.0
23-1	32.5	67.2	0.4
24-1	28.1	71.9	0.0
24-2	84.2	15.3	0.6
24-3	54.3	45.7	0.0
25-1	62.3	37.7	0.0

Table 3. (Continued)

Location number	Percent of vehicles Stopped	Rolled through	Did not slow
26-1	73.3	20.0	6.7
27-1	3.7	90.7	5.6
27-2	35.5	64.5	0.0
28-1	60.3	36.4	3.3
28-2	85.5	14.5	0.0
29-1	64.0	36.0	0.0
29-2	65.4	34.6	0.0
29-3	62.2	37.8	0.0
29-4	83.3	16.7	0.0
30-1	64.2	24.7	11.1
31-1	34.5	62.1	3.4
31-2	88.9	11.1	0.0
32-1	43.6	53.8	2.6
32-2	44.4	44.4	11.1
32-3	32.6	67.4	0.0
33-1	92.5	7.5	0.0
33-2	92.3	7.7	0.0
Average	45.4	52.4	2.2
Weighted average	36.6	61.9	1.5

The percentages shown in Table 3 are based on the observation of behavior of 5,687 vehicles. Not included is the obedience of 261 vehicles that could not be categorized. These vehicles arrived during short periods of extremely high rates of flow when the observers were unable to see vehicles at the end of a queue or more vehicles arrived than could be processed by manual counting methods. Of the vehicles omitted, 92 (35.2 percent) occurred at Location 23-1, a midblock crossing where the period of use of the temporary stop control device coincided with the time of discharge of employees from a nearby factory.

Vehicle Delay

Vehicle delay was measured only for those vehicles, 36.6 percent, that stopped. Delay was measured from the time that a vehicle's wheels ceased to rotate until forward motion was resumed. Measurements of this parameter are summarized in Table 4.

Spot Speeds

Vehicle speeds were surveyed at 18 locations during periods when the temporary stop control was not in effect. All of these were intersection locations where portable (roll-out) stop signs were in part-time use. A radar speed meter was used for this purpose. The objective of this survey was to determine typical travel speeds at the study locations for subsequent use in estimating costs of vehicle delays.

Spot speed data are generally believed to be free of significant bias due to the presence of the observer. Research personnel monitored

Table 4. Stopped delay observed at temporary school stops

Location number	Number of vehicles(1) Total	Stopped	Total delay, sec	Average delay/vehicle, sec Total	Stopped
1-1	105	97	441	4.20	4.55
2-1	174	22	71	0.41	3.23
2-2	235	40	202	0.86	5.05
3-1	64	20	104	1.63	5.20
4-1	56	10	33	0.59	3.30
5-1	138	40	66	0.48	1.65
6-1	292	43	154	0.53	3.58
6-2	128	7	17	0.13	2.43
7-1	28	6	48	1.71	8.00
7-2	26	8	59	2.27	7.38
8-1	145	38	107	0.74	2.82
9-1	102	56	170	1.67	3.04
9-2	110	102	776	7.05	7.61
10-1	90	9	33	0.37	3.67
11-1	104	67	154	1.48	2.30
12-1	208	150	711	3.42	4.74
12-2	11	11	38	3.45	3.45
13-1	98	23	94	0.96	4.09
13-2	91	12	51	0.56	4.25
14-1	32	21	96	3.00	4.57
15-1	186	124	515	2.77	4.15
16-1	15	8	56	3.73	7.00

Table 4. (Continued)

Location number	Number of vehicles(1) Total	Stopped	Total delay, sec	Average delay/vehicle, sec Total	Stopped
16-2	101	26	74	0.73	2.85
16-3	48	44	268	5.58	6.09
17-1	88	16	58	0.66	3.63
18-1	35	7	11	0.31	1.57
18-2	59	13	32	0.54	2.46
19-1	152	22	72	0.47	3.27
20-1	457	42	183	0.40	4.36
20-2	577	54	226	0.39	4.19
21-1	53	12	45	0.85	3.75
22-1	150	28	120	0.80	4.29
23-1	271	88	564	2.08	6.41
24-1	32	9	33	1.03	3.67
24-2	177	149	1002	5.66	6.72
24-3	116	63	469	4.04	7.44
25-1	61	38	97	1.59	2.55
26-1	30	22	85	2.83	3.86
27-1	54	2	5	0.09	2.50
27-2	31	11	22	0.71	2.00
28-1	151	91	219	1.45	2.41
28-2	193	165	631	3.27	3.82
29-1	25	16	37	1.48	2.31
29-2	26	17	73	2.81	4.29

Table 4. (Continued)

Location number	Number of vehicles[1] Total	Stopped	Total delay, sec	Average delay/vehicle, sec Total	Stopped
29-3	45	28	124	2.76	4.43
29-4	18	15	35	1.94	2.33
30-1	81	52	172	2.12	3.31
31-1	29	10	35	1.21	3.50
31-2	18	16	76	4.22	4.75
32-1	39	17	55	1.41	3.24
32-2	9	4	13	1.44	3.25
32-3	43	14	61	1.42	4.36
33-1	67	62	194	2.90	3.13
33-2	13	12	38	2.92	3.17
Total	5687	2079	9125		
Average				4.00	1.89
Weighted average				4.39	1.60

(1) Total includes only vehicles for which obedience was observed.

citizens' band radio channels in order to determine whether their presence had been detected and was being broadcast in this manner. The first two speed surveys were conducted from a state-owned vehicle. After only a few vehicles had passed, motorists with citizens' band radios were on the air informing others of the presence of the radar unit. This problem was not evident with subsequent speed surveys, when the observers were in private vehicles and were using a less conspicuous radar unit.

Accidents

Accident data were obtained from 52 of the 54 survey locations. Usable data were not available for two of the locations. However, there were no suitable control locations for nine survey locations, so these were also omitted from the comparative data. Those omitted included all midblock crossings because of the obvious difficulty of finding comparable control locations.

In addition to the 43 survey locations, accident data were collected for 33 other school crossings at intersections where temporary stop control devices were being used. The 76 intersections included in the accident study were located in 33 cities, 28 of which were cities where field surveys were conducted.

A control location was selected for each of the 76 intersections where temporary school stop control devices were in use. Each control location was in the same community, had a geometric configuration similar to the intersection having temporary school stop control, and vehicular traffic volumes were comparable.

The comparability of vehicular traffic volumes had to be estimated, since the scope of this project did not permit volume counting at the hundreds of intersections that were candidates for control locations. Virtually all of the control intersections were located to include one of the same streets as the intersection under study, thus helping to assure a reasonable comparability for vehicular volumes. Since the crossings studied were places at which pedestrian flow was concentrated, it was not possible to obtain control locations at which pedestrian volumes were comparable.

Accident data covering a period of at least three years were sought for each intersection. In fact, records were available for up to four years at some locations and for as little as two years at others. Hence, comparisons were made on the basis of the average number of accidents experienced per location per year.

A summary of the types of control at intersections used as control locations is presented in Table 5.

Table 5. Intersection control at locations used for accident experience comparisons

Type of control at control intersections	Number of intersections
For portable (roll-out) stop signs	
Two-way stop	26
Four-way stop	5
Yield	2
Pedestrian-actuated signal	1
No control	8
Subtotal	42
For other non-uniform stop control devices	
Two-way stops	28
No control	6
Subtotal	34
Total	76

Other Characteristics

Since the period during which the temporary stop condition was in effect varied widely at the study locations, rates of flow in vehicles or pedestrians per hour were calculated in order to afford a comparable basis for subsequent analyses. These figures are presented in Table 6. Rates of vehicular flow varied from 31 to 769 vph on the major street and 6 to 199 vph on the minor street (excluding midblock crossings). Pedestrian rates of flow varied from 0 to 327 persons/hour.

Observers were at 39 of the 54 survey locations at or before the time the temporary control was scheduled to be effectuated. In other cases, this time had not been reported or had no practical meaning (as in the case of a survey made in the afternoon at a location where the temporary control was in effect of the entire school day). At 12 of these 39 locations the actual installation took place within five minutes of the reported time. Installation was late by as much as 56 minutes at 15 locations. Installation was early at 12 locations by up to 55 minutes, although one non-uniform stop control device scheduled for early morning effectuation had apparently been left in the STOP position during the entire previous night.

Street widths for school crossings at the field survey locations where temporary stop control devices were used varied from 18 ft to 50 ft. The average width was 30 ft.

Table 6. Vehicular and pedestrian rates of flow at temporary school stop locations

Location number	Measurements period, min	Volumes: Major street vehicles	Volumes: Minor street vehicles	Volumes: Pedestrians	Rates of flow, per hr: Major street vehicles	Rates of flow, per hr: Minor street vehicles	Rates of flow, per hr: Pedestrians
1-1	34	108	42	16	191	74	28
2-1	78	175	24	30	135	18	23
2-2	81	239	159	47	177	118	35
3-1	21	67	18	28	191	51	80
4-1	36	57	15	38	95	25	63
5-1	43	139 (1)	58	22	194 (1)	81	31
6-1	52	294	40	17	339	46	20
6-2	56	128	11	4	137	12	4
7-1	11	29	25	45	158	136	245
7-2	13	16	12	49	74	54	226
8-1	27	149	20	25	331	44	56
9-1	22	106	15	16	289	41	44
9-2	11	141	9	60	769	49	327
10-1	42	91	9	31	130	13	44
11-1	72	104	26	45	87	22	38
12-1	40	222	60	57	333	90	86
12-2	14	11	2	45	47	9	193
13-1	40	98	50	136	147	75	204
13-2	70	91	29	17	78	25	15
14-1	46	32	9	32	42	12	42
15-1	30	188	64	2	376	128	4
16-1	13	9	9	32	42	42	148
16-2	42	105	139	18	150	199	26
16-3	21	52	-	18	149	-	52
17-1	40	88	6	17	132	9	26
18-1	27	37	4	15	82	9	33
18-2	42	60	13	23	86	19	33
19-1	79	152	8	2	115	6	2
20-1	64	470	13	25	441	12	23
20-2	145	581	200	5	240	83	2
21-1	36	53	16	14	88	27	23
22-1	41	152	37	14	222	54	20
23-1	67	363	-	171	325	-	153

Table 6. (Continued)

Location number	Measurements period, min	Volumes: Major street vehicles	Volumes: Minor street vehicles	Volumes: Pedestrians	Rates of flow, per hr: Major street vehicles	Rates of flow, per hr: Minor street vehicles	Rates of flow, per hr: Pedestrians
24-1	41	37(1)	39	48	54(1)	57	70
24-2	47	201	113	46	257	144	59
24-3	25	126	44	73	302	106	175
25-1	50	49	24	43	59	29	52
26-1	30	30	-	51	60	-	102
27-1	76	39	17	7	31	13	6
27-2	33	23	9	5	42	16	9
28-1	60	157	23	19	157	23	19
28-2	40	197	13	0	296	20	0
29-1	11	25	4	2	136	22	11
29-2	4	30	10	0	450	150	0
29-3	15	46	17	3	184	68	12
29-4	13	15	3	29	69	14	134
30-1	43	83	9	16	116	13	22
31-1	14	21	9	20	90	39	86
31-2	11	19	11	8	104	60	44
32-1	8	39	4	24	292	30	180
32-2	4	9	3	0	135	45	0
32-3	23	44	37	62	115	97	162
33-1	42	67	9	21	96	13	30
33-2	9	13	-	18	87	-	120
Average					172	47	67

(1) Data are incomplete due to field equipment malfunction.

V. ANALYSES

Accident Experience

The accident experience at 76 intersections using temporary school stop control devices and at 76 comparable control locations is summarized in Table 7.

It was recognized that a few intersections with very high accident experience could distort a comparison of averages for

Table 7. Accident experience comparisons

Type of control at control intersection	Number in each sample	Accident experience, accident/yr Study	Control
For portable (roll-out) stop signs			
Two-way stop	26	0.57	0.72
Four-way stop	5	0.43	0.50
Yield	2	0.51	0.00
Pedestrian signal	1	0.67	1.00
No control	8	0.48	0.45
Subtotal	42	0.54 (Average)	0.61
For other non-uniform stop control devices			
Two-way stop	28	0.42	0.26
No control	6	0.06	0.28
Subtotal	34	0.36 (Average)	0.26
For total sample			
Total	76	0.456 (Average)	0.454

the study locations and the control locations, given the small sample size involved. Hence, a comparison by accident rates at individual intersections was undertaken. These data are presented in Table 8. Only one intersection in either sample experienced more than 2.0 accidents/year; this was a control intersection with an average of 2.70 accidents/year. None of the differences displayed in Table 7 and 8 between the study locations and control locations is statistically significant.

Because of the nature of this research, particular attention was directed to accidents involving pedestrians. Seven pedestrian accidents were noted of the 220 accidents that were recorded as part of the comparative sample for this research. Three of these accidents occurred at study locations and four at control locations. Only one accident involved children making a trip to or from school at at crossing protected by a temporary stop sign. This accident occurred when two children passed between cars stopped due to downstream congestion in one traffic lane and were struck when they entered another lane (on a four-lane street) in which traffic was still moving. Other pedestrian accidents involved adults or children who were not in a protected crossing under circumstances not related to the type of intersection control.

A regression analysis was undertaken using the accident frequency/year as the dependent variable. The independent or explanatory variables that were tested in this and subsequent analyses are described in Table 9 (except that X_{15} was not used to describe accident frequency). A resulting expression that includes only those variables significant with

Table 8. Comparisons by accident frequency at individual intersections

Type of control at control intersection	Number of intersections: Study intersections Accidents/location/yr 0.00	0.01 to 1.00	over 1.00	Control intersections Accidents/location/yr 0.00	0.01 to 1.00	over 1.00
For portable (roll-out) stop signs						
Two-way stop	10	10	6	9	9	8
Four-way stop	2	2	1	2	2	1
Yield	1	0	1	2	0	0
Pedestrian signal	0	1	0	0	1	0
No control	3	3	2	5	1	2
Subtotal	16	16	10	18	13	11
For other non-uniform stop control devices						
Two-way stop	11	13	4	16	9	3
Four-way stop	5	1	0	3	3	0
Subtotal	16	14	4	19	12	3
For total sample						
Total	32	30	14	37	25	14

0.95 probability is as follows:

$$Y = 0.19 + 0.00214X_1 + 0.00490X_2 \qquad R^2 = 0.46$$
$$(4.27) \qquad (3.27)$$

where, Y = number of accidents/year

X_1, X_2 as defined in Table 9

Values for the t-statistic are indicated in parentheses beneath the equation. With 49 degrees of freedom, a t-statistic greater than 2.01 indicates that a regression coefficient is significant with a probability greater than 0.95.

Table 9. Explanatory variables used in regression analyses

Variable	Definition	Unit or code
X_1	Major street rate of flow	veh/hr
X_2	Side street rate of flow	veh/hr
X_3	Pedestrian rate of flow	ped/hr
X_4	Type of device	
	Portable (roll-out) sign	1
	Other non-uniform stop sign	0
X_5	Number of marked crosswalks (major street only)	
	Two	2
	One	1
	None	0
X_6	Location relative to school	
	Adjacent to school	2
	Within a block of school	1

Table 9. (Continued)

Variable	Definition	Unit or code
	Remote location	0
X_7	Posted speed in mph (major streets only)	
	35 or more or none	4
	30	3
	25	2
	20	1
X_8	Approach visibility (major street only)	
	Good	2
	Fair	1
	Poor	0
X_9	Marking conditions	
	Good	3
	Fair	2
	Poor	1
	None	0
X_{10}	Time of study	
	P.M.	1
	A.M.	0
X_{11}	Presence of crossing guard(s)	
	Yes	1
	No	0
X_{12}	Type of stop sign	
	Four-way	1

Table 9. (Continued)

Variable	Definition	Unit or code
	Two-way, one-way or other	0
X_{13}	Type of intersection (location)	
	Four-way intersection	2
	T intersection	1
	Midblock crossing	0
X_{14}	Population classes	
	50,000 and over	6
	10,000-49,999	5
	5,000-9,999	4
	2,500-4,999	3
	1,000-2,499	2
	Not over 999	1
X_{15}	Team conducting the field survey	
	A	1
	B	0

No other explanatory variables appeared in an equation at this significance level. The coefficient of determination, R^2, of 0.46 indicates that 46 percent of the variability in the independent variable from a mean value of 0.43 accidents/year is explained by this equation. The data set included those 52 of the 54 survey locations for which accident data were available.

Appendix E presents a simple correlation matrix. This matrix indicates the correlation coefficient between Y and each explanatory variable, using only the set of 52 study locations for which accident data were available. Also indicated in Appendix D are the correlations between each pair of explanatory variables and their correlations with the dependent variables used in the analyses described in the following section of this report. The latter correlations are for the full set of 54 locations, and therefore may not coincide exactly with the correlations among explanatory variables for the set of 52 locations used in the analysis of accident frequency.

Obedience, Vehicle Delay, and Speed

A number of regression analyses were undertaken to determine whether the obedience to stop control devices or the amount of stopped delay were significantly correlated with specific characteristics of locations where temporary school stop control devices were in use. All of the explanatory variables listed in Table 9 were tested for this purpose. Spot speed data were analyzed to determine the free-flow speed characteristics at representative locations using portable (roll-out) stop signs.

Obedience to Stop Control

An expression describing the level of obedience to temporary stop control devices was developed by regression analysis of the data from this study. This expression is as follows:

$$Y_1 = 68.67 + 19.56X_{11} - 44.19X_{15} \qquad R^2 = 0.68$$
$$(3.95) \qquad (-9.07)$$

where, Y_1 = percentage of vehicles stopping

X_{11}, X_{15} as defined in Table 9

Values for the t-statistic are indicated in parenthesis beneath the equation. With 51 degrees of freedom in this case, a t-statistic greater than 2.01 indicates significance of a regression coefficient with a probability greater than 0.95.

No other explanatory variables appeared at this level of significance. The appearance of X_{15} in the equation indicates that there probably was a systematic bias in the recording of data in the field. One of the field survey parties apparently interpreted the definition of a complete stop differently than the other party. The effect of this bias was that the party interpreting a complete stop less rigorously recorded an average of 44 percent more vehicles stopping than the other party. Of greater importance, this equation demonstrates that the effect of an adult crossing guard or school patrol member was to induce an increase of nearly 20 percent in the proportion of vehicles stopping at a crossing.

The simple correlation coefficients between Y_1 and each explanatory variable, and among explanatory variables, are tabulated in Appendix E. To aid the reader in interpreting this table, a correlation coefficient with an absolute value in excess of about 0.30 may be considered to indicate a correlation between variables that is consequential, although not necessarily significant form a statistical standpoint. For example, the correlation of 0.051 between Y_1 and X_4 indicates a tendency for fewer vehicles to stop at portable (roll-out) stop signs than at other non-uniform devices, but also indicates a relationship so weak that it bears no practical significance.

A separate analysis was conducted using the presence or absence of a warning sign in advance of the crossing an an independent variable. The results indicated that there was no significant relationship between this variable and the obedience to temporary stop control.

The level of obedience observed in this study averaged 36.6 percent, indicating a substantial lack of adherence to the legal requirements imposed by stop controls. In order to determine whether this was unique to temporary school stop control devices, an additional 16 intersections in central Iowa that had permanent stop control were studied. The proportion of vehicles that were observed to stop completely at eight permanent two-way stop intersections varied from 15.7 percent to 70.1 percent, with a weighted average of 48.2 percent. A significant positive correlation was noted between the percentage stopping and the cross-street (major street) volume. At eight permanent four-way stop intersections, the weighted average was 23.3 percent of vehicles stopping. The range was from 8.8 percent to 40.6 percent. The highest percentage of stops occurred at a permanent four-way stop location adjacent to a school. This intersection was functioning in a manner similar to those studied that were controlled by temporary stop control devices.

Vehicle Delay

An analysis to establish the relationship between vehicle delay and the explanatory variables given in Table 9 resulted in the following equation:

$$Y_2 = 2.71 + 0.0104X_2 + 0.0119X_3 \qquad R^2 = 0.44$$
$$(2.84) \qquad (5.35)$$

where, Y_2 = stopped delay/stopped vehicle, sec

X_2, X_3 as defined in Table 9

No other explanatory variables appeared at a significance of at least 0.95. The table in Appendix E also gives the correlation between Y_2 and each explanatory variable.

Spot Speeds

Data on spot speeds that were obtained when the temporary stop control was not in effect are displayed in Table 10. Analysis included a determination of the mean, 15th and 85th percentile speeds, and the 10-mph pace. (The pace is defined as that 10-mph range of speeds that includes the greatest number of observed values.)

With the exception of Location 28-1, the 10-mph pace at each location included more than 69 percent of the observed speed values. These high percentages indicate a relatively uniform speed distribution which, in turn, suggests that operating conditions tend to be much safer than when speeds are widely dispersed. It may be noted, however, that the mean observed speed exceeds the speed limit at 11 of the 18 locations. The 85th percentile speed exceeds the speed limit at 16 locations.

Economic Analysis

Economic costs for vehicle and pedestrian delays, and for installing or fabricating and operating the devices used, afford a basis for comparing different types of control. Costs were calculated and compared

Table 10. Analysis of survey of spot speeds

Location number	Posted speed, mph	Mean speed mph	Standard deviation, mph	Median speed, mph	15th percentile speed, mph	85th percentile speed, mph	10-mph pace	Percent in 10-mph pace
1-1	25	28.1	5.74	27	23	34	22-32	69.2
2-1	25	29.1	4.03	29	24	33	23-33	80.0
2-2	25	28.9	3.84	29	25	32	24-34	83.3
9-1	(1)	28.5	3.12	28	25	32	24-34	94.7
9-2	25	22.0	3.08	21	19	25	18-28	90.8
12-1	25	26.1	4.12	26	23	31	23-33	78.3
15-1	35	31.6	5.54	32	27	37	28-38	70.9
20-1	20	30.5	4.05	30	25	35	25-35	78.4
20-2	20	22.5	3.76	22	18	26	17-27	87.7
21-1	25	25.7	4.62	25	21	30	20-30	74.3
24-3	35	33.0	5.79	33	28	37	28-38	70.1
28-1	35	42.2	8.62	40	33	51	37-47	48.9
28-2	30	29.8	3.42	29	27	34	26-36	87.9
29-2	(1)	26.8	3.54	26	24	31	22-32	84.6
29-3	(1)	27.9	3.91	27	25	31	25-35	83.1
29-4	(1)	21.1	5.19	21	16	24	16-26	81.5
31-1	(1)	24.4	3.49	24	21	28	20-30	88.6
31-2	25	27.3	3.90	27	24	31	22-32	83.3

(1) No speed limit posted, 25 mph under provisions of Code of Iowa.

for three types of stop control devices employed for this purpose at school crossings. They are as follows:

1. Temporary stop control.
2. Permanent four-way stop signs.
3. Midblock pedestrian-actuated signals.

Pedestrian delays are inconsequential for all of these types of control and therefore were not included in the calculation. Other comparisons were made on the basis of a typical intersection, using the following values that were averages for the 54 survey locations:

- Major street vehicular rate of flow, 176 vph
- Minor street vehicular rate of flow, 47 vph (where applicable)
- Pedestrian crossing rate of flow, 67 persons/hr
- Free flow vehicle speed, 28.08 mph

All vehicles were assumed to be passenger automobiles.

It should be noted here that these vehicular and pedestrian rates of flow, typically encountered where temporary school stop control devices are used in Iowa, are quite low. They are not sufficiently high to satisfy the warrant commonly employed to justify use of a midblock pedestrian-actuated signal. This type of control has generally been suggested only where vehicular volumes do not permit an average of at least one gap/minute suitable for pedestrian crossings. Signals are not usually considered where suitable gaps occur more frequently. Assuming random arrival of vehicles and using the criteria of Reference 6 to define a suitable gap (12 seconds in this case), these occur an average of about 98 times/hour or once every 37 seconds when the vehicular volume is 176 vph and one row of pedestrians is crossing a street

30 ft wide. The warrant is satisfied only when traffic volumes are much higher (400 to 1,000 or more vph, depending upon street width and pedestrian volumes).

Unit Costs

Unit costs for passenger vehicle operation to effect speed reductions, including stops, and for idling while stopped were obtained from Reference 27. Costs given in this reference are for January 1975. These were updated to November 1977, by using appropriate multipliers. Each multiplier is a function of different proportions of certain detailed indices from the Consumer Price Index. Equations for the multipliers are also given in Reference 27. The multipliers calculated for this purpose were 1.165 for speed changes and stops, and 1.200 for idling.

The time delay due to reductions in speed were obtained from Winfrey (28). This gives values for the amount of time for deceleration to a reduced speed, and then for acceleration to regain the free-flow speed (28.08 mph in this case). Stopped time delay is in addition to the acceleration and deceleration delays.

A value for the time of vehicle occupants had to be assumed. A study by Thomas and Thompson that related the value of time of vehicle occupants to the amount of time saved, trip purpose and other factors, found that persons place a much lower value per unit of time on very small increments of time saved, and high values on time savings of several minutes each (29). Since the amount of time involved in a single speed change was only a few seconds, and since most of the traffic consisted of local vehicles, probably making a short trip, a relatively low value for time is suggested. The value of $2.00/hour covering the time of all occupants of a vehicle has been utilized. However, time costs have been segregated from all other costs, so that a reader electing to use a value higher or lower than $2.00/vehicle-hour may readily evaluate the effects of time costs on the economic calculations.

The following costs for installation and operation of stop signs and signals were obtained from traffic engineers in municipalities in Iowa, and were used in subsequent cost calculations:

- Fabrication and installation of stop signs for temporary use, $80 each or $160/intersection.
- Fabrication and installation of permanent stop signs, $50 each or $100/intersection.
- Costs for midblock pedestrian signal, per crossing:

  Initial installation, $10,000.

  Maintenance, $10/month or $120/year.

  Purchase of power, $20/month or $240/year.

These costs will be segregated from other costs in summaries so that the reader may substitute locally applicable costs where appropriate.

Temporary Stop Control

In order to calculate vehicle delays and operating costs at temporary school stops, the personnel conducting field surveys estimated the speeds attained by vehicles that slowed but did not stop. The values used for this calculation were as given in Table 11. Unit costs were interpolated from Reference 27 for speed reductions from 28.1 mph to each of the other speeds. Considering also the average stopped delay of 4.00 seconds/stopped vehicle, operating costs for speed reductions and stops, updated to November 1977, were \$13.366/1,000 vehicles (\$13.184 for acceleration and deceleration and \$0.152 for idling).

The time lost for speed reductions and stops was 3.182 hours/1,000 vehicles (2.775 hours for acceleration and deceleration and 0.407 hour for idling). This is an average total delay of 11.46 seconds/entering vehicle. The time cost therefore was \$6.364/1,000 vehicles using the unit cost of \$2.00/vehicle-hour.

Table 11. Estimated speeds at temporary stop signs

Slowest speed attained, mph	Proportion of total vehicles
0 (stopped)	0.36
2.5	0.40
5	0.15
10	0.04
15	0.02
20	0.015
28.1 (did not slow)	0.015
Total	1.00

The temporary stop control devices encountered in this study were in effect an average of 3.25 hours/day. Each one would affect 572 major street vehicles/day at a rate of flow of 176 vehicles/hour. Using these values and the unit costs above, daily costs were calculated at \$11.27/day, \$7.63 for vehicle operation and \$3.64 for the time of vehicle occupants. Since schools in Iowa are in session for 180 days, annual cost would be \$2,028.60/year, \$1,373.40 for vehicle operation and \$655.20 for the time of vehicle occupants.

Methods for installing or effectuating temporary stop control devices were found to vary widely. Some cities hired an individual specifically for this purpose and thereby incurred a direct and readily calculable cost. More often, however, a teacher or custodian at a school performed this duty so that costs were indirect and less readily calculable. Where a sign was installed by a police officer, costs were fairly substantial but could not be determined easily. Students effected installation and removal in a few cities. Given this variation, a unit cost of \$1.00/cycle of installation and removal has been assumed to cover the average situation where some cost was incurred for installation by a person receiving a salary or wages primarily to perform other duties. Since the average sign in Iowa was installed or effectuated 2.23 times/day, this yields an average cost of \$2.23/day or \$401.40/year for 180 days.

Similar calculations were made for an assumed condition where each vehicle stopped completely and incurred 4.00 seconds of stopped delay. Total annual costs for these two conditions are summarized in Table 12. Note that these vehicles costs are for major street vehicles only. The mode of operation of minor street vehicles (stop, then proceed when the major route is clear) ordinarily is not changed by the use of temporary stop control devices.

Permanent Four-way Stop Control

Use of temporary stop control devices typically converts a two-way stop intersection into a four-way stop intersection during the period of use of the temporary devices. Some cities in Iowa have made this conversion permanently. An evaluation was made of the economic effects of this conversion.

The unit costs applicable in this case are the same as those previously calculated for temporary stop control devices. The essential

Table 12. Summary of annual costs for temporary stop control

	Costs, $/year	
Cost item	As operating	If each vehicle stopped
Vehicle operating	$1,373.40	$1,604.61
Time of vehicle occupants	655.20	904.22
Installation and removal	401.40	401.40
Total	$2,430.00	$2,910.23

difference is that the effect accrues for 24 hours/day and 365 days/year, rather than for 3.25 hours (average)/day and 180 days/year. In order to determine the average proportion of daily traffic affected by temporary control devices, typical hours of usage were determined. The proportion of daily traffic affected during these hours could them be estimated.

Hours of use were analyzed from the questionnaire responses. Each of nine daily hours were found to include some usage, with the most extensive use occurring between 8:00 and 9:00 a.m. and 3:00 and 4:00 p.m. The proportion of daily traffic occurring during each hour was taken from a report by Box and Alroth (30). (This report distinguishes between major arterials and minor streets. The proportion of average daily traffic occurring on each type of route for each hour is given. These two values were averaged for this analysis to be representative of streets in Iowa on which temporary stop control devices typically are located.)

This analysis indicated that 20.0 percent of the average daily traffic occurred during the 3.25 hours that the temporary school stop control was in effect. A total daily traffic on the major street of 2,860 vehicles would correspond to the 572 vehicles affected by the temporary device. On this basis, annual costs for major street vehicles only with permanent four-way stop control were calculated, as displayed in Table 13. Again, two modes of operation are considered. In addition to the observed experience with only about 36 percent of the vehicles stopping, an evaluation is also shown based on an assumption that all vehicles stopped and incurred 4.0 seconds of stopped delay/vehicle.

Table 13. Summary of annual costs for permanent four-way stop control

Cost item	Costs, $/year	
	As operating	If each vehicle stopped
Vehicle operating	$13,925.63	$16,268.95
Time of vehicle operation	6,639.20	9,167.76
Total	$20,564.83	$25,436.71

Midblock Pedestrian-Actuated Signal

In order to analyze the effect of vehicular and pedestrian traffic on a midblock crossing using pedestrian actuated signals, a simple program was executed that simulated the arrival of pedestrians and vehicles. The signal was adjusted to respond appropriately to pedestrian actuations. The assumptions used as input for this program were as follows:

- The pedestrian flow of 67 persons/hour consisted of 40 groups of pedestrians arriving randomly throughout the hour.
- A pedestrian would place a demand for a WALK signal immediately upon arrival at the crossing.
- A minimum of 30 seconds of green was provided after each pedestrian cycle. Once this minimum was satisfied, a pedestrian call would cause the signal to cycle through 4.0 seconds of vehicle clearance (yellow), 7.0 seconds of WALK, and 8.0 seconds of flashing DONT WALK. Thus, each vehicle red signal was displayed for 15 seconds.
- A vehicle stopped if it arrived during the red indication or during the last 2.0 seconds of the yellow.
- A vehicle proceeded without reducing speed if it arrived during the first 2.0 seconds of the yellow, or any except the first 5.0 seconds of the green signal indication.
- A vehicle slowed to a speed varying from 5 to 20 mph if it arrived during the first 5.0 seconds of the green signal indication.
- The vehicular flow of 176 vehicles/hour was assumed to arrive at uniform intervals.

The results of this simulation are as follows:

- Of 176 vehicles/hour, 80 percent proceeded without slowing, 4 percent slowed, and 16 percent stopped.
- Total vehicle delay averaged 641 seconds/hour including 267 seconds of stopped delay. This was an average of 3.64 seconds/entering vehicle.
- The average pedestrian delay was 7.50 seconds/person.

It was further assumed that pedestrian flow at this rate was sustained for 2.5 hours/day for 180 days/year. Using the same unit costs as for stop sign control, annual vehicle costs at pedestrian signals would be \$412.03, including \$251.77 for vehicle operation and \$160.26 for the time of vehicle occupants. Costs for maintenance of signal equipment and purchase of power bring the total annual cost to \$772.03.

Summary of 20-Year Costs

To make a valid economic comparison among alternative forms of intersection control, costs for the purchase and installation of signs or signal systems must be added to the costs for time, vehicle operation, and periodic maintenance and operation of the system. Such a comparison may be madê by relating all costs over a 20-year period, the assumed service life of a sign or signal installation.

Installation costs are incurred at one time at the beginning of an analysis period. Other costs accrue annually during each year of the period. A comparison may be made only if costs incurred in the future are suitably discounted to account for the time value of money, the effects of inflation, and the possibility of changes in vehicular and pedestrian volumes. A discount rate of 8.0 percent was selected for this purpose. A uniform cost occurring annually in the future may then be related to a current expenditure by multiplying the annual amount by a series present worth factor. The series present worth factor for a discount rate of 8.0 percent and a 20-year analysis period is 9.818147.

A comparison of the 20-year present worths of costs for the three control methods analyzed is presented in Table 14. Values for control by stop signs assume the level of obedience that was observed in this study. It should be noted that this comparison is valid only for the vehicular and pedestrian volumes that are averages for the 54 locations where field surveys were conducted as part of this study, and for the

Table 14. Present worth of 20-year costs for three alternative methods of control

	Total 20-year costs, $		
	Method of control		
Cost item	Temporary stop	Four-way stop	Pedestrian signal
Fabricate and install signs (0)	$ 160	$ 100	$ -
Procure and install signals (0)	-	-	10,000
Install and remove signs (A)	3,941	-	-
Purchase power (A)	-	-	2,356
Maintain signals (A)	-	-	1,178
Vehicle operation (A)	13,484	136,724	2,472
Time of vehicle occupants (A)	6,433	65,185	1,574
Total	$24,018	$202,009	$17,580

0 = one time expenditure, A = annual expenditure.

unit costs assumed. In general, higher vehicular volumes will tend to make the comparison more favorable for pedestrian signals. Higher pedestrian volumes or wider streets will have an opposite effect.

No cost analysis was made for intersection control by traffic-actuated signals. The volumes encountered at typical intersections using temporary stop control are much too low to warrant traffic signals. If they were used, however, control by traffic-actuated signals would induce costs for major street vehicular delays about the same as were calculated for permanent four-way stop control. These costs would be offset somewhat by a decrease in costs that could be anticipated from a reduction in delays to minor street vehicles. Capital costs for the signal installation and costs for maintenance and purchase of power would be about double the comparable costs for pedestrian-actuated signals.

Summary of Findings

There is no indication from the results of this research that temporary stop control devices at school crossings either increase or decrease accident frequency. None of the differences in accident experience between intersections using temporary school stop control devices and comparable control intersections was statistically significant. However, there was much greater pedestrian exposure at the study intersections.

Obedience to stop control at locations controlled by temporary devices was relatively low. Only 36.6 percent of the vehicles observed came to a complete stop. However, a study of 16 intersections controlled by permanent stop signs indicated comparable levels of obedience. This finding suggests that there is no significant difference in motorist response to permanent stop signs and temporary stop signs.

Vehicle delays are significant at all types of stop signs. However, the temporary nature of the device studied reduces these delays substantially when compared with permanent stop signs. Pedestrian-actuated signal control at midblock locations may be expected to cause significantly less vehicle delay than temporary stop signs.

An economic analysis of costs for vehicle operation, vehicle delays, and the costs for installing and operating various devices indicates that long-range savings are possible by using midblock pedestrian-actuated signals rather than temporary stop signs. This analysis also indicates that conversion to permanent four-way stop control from temporary control, or one that is responsive to actual pedestrian demand during limited periods, will always entail a substantial increase in costs.

Times of installation and removal of temporary school stop control devices were found to be quite erratic at the locations surveyed in the field. In some cases, the times the devices were used did not correspond with periods of pedestrian demand. The accident hazard for school children is increased significantly when crossings are made at a location normally having stop control, but lacking that control due to a failure to effectuate the temporary device. On the other hand, additional costs for vehicle delay and operation are needlessly incurred when these devices are left in effect beyond the period of need.

Designs of temporary school stop control devices in Iowa are widely variable. Some typical portable signs are displayed in Figure 1, and some of the other non-uniform signs are shown in Figure 2. Most of the portable stop signs in use are mounted much too low to be effective when placed in position. Few of these conform to a standard design prepared in 1973 by the Iowa State Highway Commission (now part of the Iowa Department of Transportation). A copy of this standard design is included as Appendix F.

Patterns of use also are widely variable. Many portable signs are placed in the center of an intersection and display four stop sign faces in order to function as four-way stops. At intersections with permanent two-way stop control, some communities use a single two-way sign also placed in the center of an intersection. Other cities use a separate sign on each approach.

The use of flashing beacons in conjunction with temporary school stop control also involves some non-uniform practices. In one instance a flashing red beacon operated on an automatic timer, and started and stopped at times that did not coincide with the times that a temporary non-uniform stop sign was in effect. Some communities use flashing red beacons for part-time stop control at crossings permanently marked only with standard crosswalk warning signs. The effect, if any, on motorist response to the non-uniform practices that were observed could not be determined.

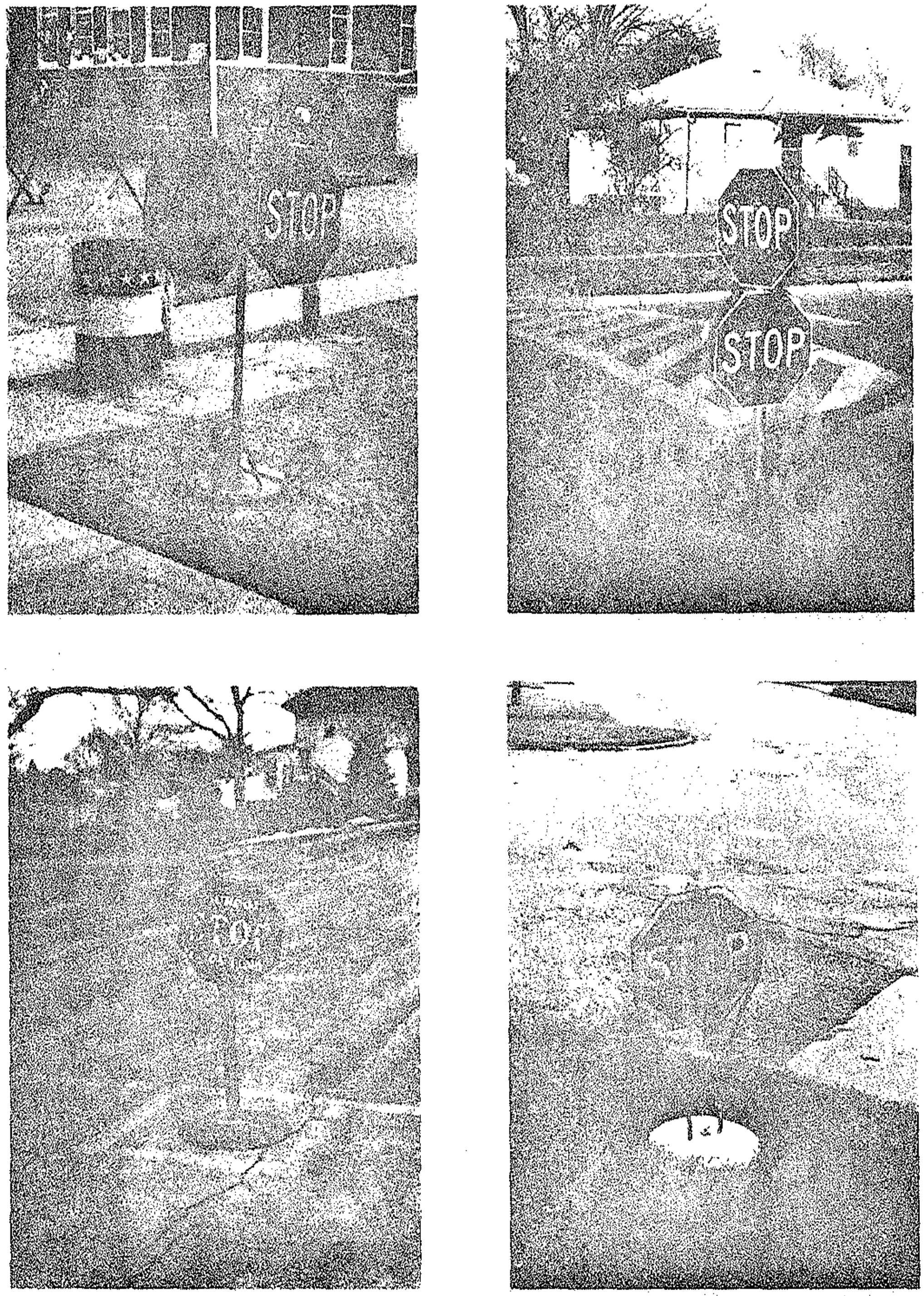

Figure 1. Photographs of typical portable (roll-out) stop signs

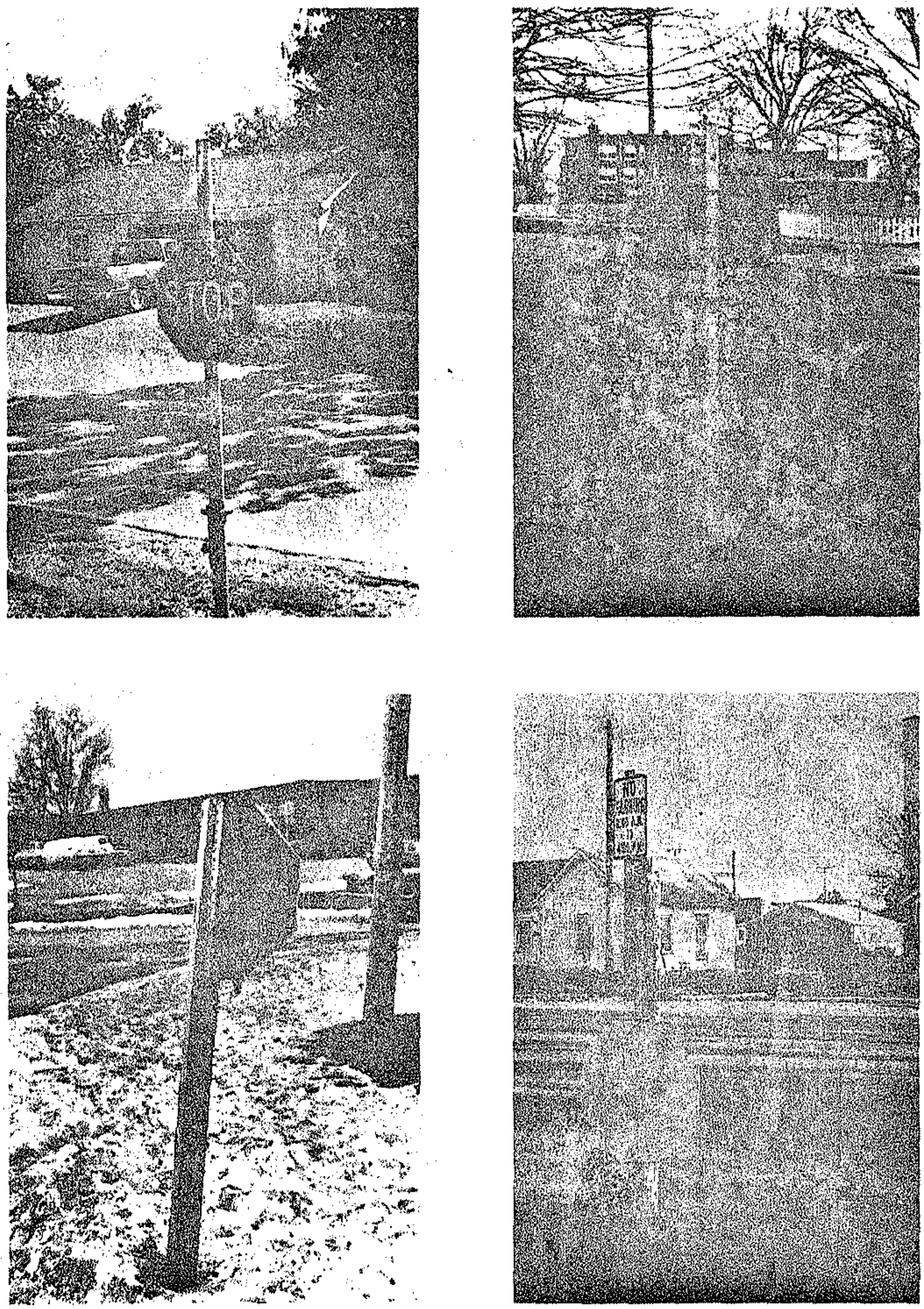

Figure 2. Photographs of other types of non-uniform stop signs

VI. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

A substantial majority of the officials from the over 300 communities in Iowa that use temporary stop control devices at school crossings favor the use of these devices. They also believe that their use serves to reduce accident frequency.

The results of this study indicate that accident experience is the same at locations using these devices as at comparable locations not using the temporary devices. The fact that the greater pedestrian exposure at locations using temporary stop control devices was not reflected by an increase in pedestrian accidents suggests that the use of these devices is serving to prevent accidents involving children making trips to and from school.

The most serious objection to use of temporary stop control devices is their lack of consistency with accepted standards for uniform traffic control devices. This objection is raised by users of these devices as well as by non-users. National standards do not approve their use. Lack of uniformity in Iowa is manifested in the design and placement of the signs. The extent of which this troubles motorists could not be ascertained in this research. A lack of uniformity apparently did not result either in a reduced level of obedience to the temporary devices or in an increase in the frequency of occurrence of accidents.

Any move to prohibit the use of non-uniform traffic control devices faces the practical problem of enforcing such a prohibition. There currently are no practicable means by which the state can enforce a legal requirement that cities conform with the provisions of a manual on uniform traffic control devices. The current popularity of non-uniform stop control devices used at school crossings strongly implies that efforts to prohibit their use would be resisted by local citizens and officials who have become accustomed to them and believe that they are effective. An indication that this problem may not be unique to Iowa is afforded by the frequency with which other states indicated that illegal or unsanctioned use of portable stop signs occurs regularly in local jurisdictions.

A more useful role for the state would be to guide and assist cities in seeking improved means for providing protection at school crossings. Alternatives to temporary stop signs, such as pedestrian-actuated signals at midblock crossings, can be shown to be cost-effective. They also would provide a comparable degree of protection against accidents in many locations. In some cases, one midblock crossing can replace two crossings that currently use temporary stop signs, with significant savings in costs and delays to vehicular traffic and no sacrifice in pedestrian protection.

Guidance from the state in establishing standards for the design and use of temporary devices is also needed. The devices in use are often poorly designed. Their locations are not always consistent with appropriate school route plans. The times during which they are used are frequently excessive in terms of their intended use for protecting school crossings. Temporary signs may be effectuated and removal may be too early or too late, either needlessly disrupting vehicular traffic flow or affording inadequate pedestrian protection at crossings or both.

Recommendations

The findings and conclusions from this study do not support a prohibition of the use of portable signs placed in the roadway. However, they do suggest that significant benefits could be realized by reducing restrictions to vehicular traffic flow without an adverse effect on safety. Accordingly, the following nine recommendations are suggested by these conclusions:

1. Changes in Legislation

No change is suggested now in the current legislation covering the use in Iowa of temporary stop control devices at school crossings. However, following preparation of a new school crossing manual by the Iowa Department of Transportation, a change in Section 321.252, Code of Iowa, should be effected to require adherence to provisions of this manual. Wording should also be changed to permit use of these devices at authorized school crossings rather than to "delimit school zones," and to permit the use of temporary stop control devices placed at the side of the road.

2. Preparation of a School Crossing Manual

The Iowa Department of Transportation should prepare a school crossing manual that will include the following items, among others:

a. Guidelines for establishing a school route plan.

b. Reference to sources of assistance for establishing school patrols or administering a crossing guard program.

c. Incorporation of standards governing use of temporary stop control devices at school crossings suggested by recommendations 3 through 8.

3. Restudy of Current Use of Temporary School Stop Control Devices

Locations at which temporary stop control devices are currently in use should be studied with a view toward either eliminating stop control or substituting a feasible and effective alternative form of control. Where such study indicates that a temporary stop control device is necessary, preference should be given to devices located at the side of the roadway rather than within the roadway. The use of pedestrian-actuated signals should be investigated.

4. Standard Designs

A standard design should be prepared for roadside-type temporary school stop control devices, and should be included in an updated Iowa school crossing manual. A suitable design should display a standard school crossing warning sign when stop control is not in effect. The current standard for portable stop signs (dated September 7, 1973) should be included in the manual.

5. Location of Portable Signs

Portable (roll-out) stop signs, if used, should be located in advance of each crosswalk for which protection is desired. They should not be located in the center of an intersection so that a single sign is intended to afford protection for two or more crosswalks.

6. Pavement Markings

Each crosswalk protected by a stop control device should be marked in conformance with current standards for pavement markings.

7. Warning Signs

Standard warning signs (S1-1) should ordinarily be used preceding crossings controlled by temporary stop control devices. Guidelines for their use should be included in the updated Iowa school crossing manual.

8. Hours of Use

Specific instruction should be included in an Iowa school crossing manual for determining the time periods during which a temporary school stop control device should be effectuated. This process should include field studies to establish periods of significant pedestrian flow. Installation generally should cover two periods of limited duration per school day, one each in the morning and afternoon. A third period during a noon break may be necessary if children ordinarily walk to and from school at this time. All-day installation ordinarily would be discouraged.

9. Request for Approval and Inclusion in MUTCD

The results of this study, including conclusions and recommendations, should be communicated to the Federal Highway Administrator with a request that Section 7B-6 of the Manual of Uniform Traffic Control Devices be modified to permit the use of portable school signs placed in the roadway, if their use is in accordance with applicable state laws and is consistent with standards of practice promulgated by a state agency having responsibility for the application of traffic control devices within the state.

ACKNOWLEDGMENTS

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Advice and assistance to the research team was provided by an Advisory Panel consisting of the following persons:

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The interpretations of research results, opinions, findings and conclusions expressed in this publication are those of the authors, and are not necessarily consistent with the opinions of members of the Advisory Panel or the Highway Division of the Iowa Department of Transportation.

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APPENDICES

APPENDIX A

QUESTIONNAIRES AND LETTERS OF TRANSMITTAL

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 13, 1977

(Initial questionnaire to cities)

The Engineering Research Institute at Iowa State University is undertaking a research study for the Iowa Department of Transportation entitled "Portable School Stop Signs and Other Non-Uniform School Stop Control Devices". As you may be aware, portable stop signs, altough permitted under Iowa law to delineate school zones, do not conform with federal standards. An objective of our research is to establish the benefits, if any, of their use and to make an evaluation of whether to recommend changes in either federal requirements or state law. We need your assistance in carrying out this research responsibility.

The purpose of this inquiry is to determine whether portable (roll-out) stop signs are or have recently been used at school crossings in your community. You are requested to indicate this on the enclosed questionnaire. A further subject of our investigation is the use of other types of school signs that display a STOP message only during certain hours. This is usually effected by means of a sign that folds or is rotated to vary the message displayed to motorists. The questionnaire also has a space for indicating the use of this type of device. If neither of these types of devices is used, please indicate this on the questionnaire and return it to us using the enclosed prepaid envelope.

If any of these devices are used currently or have been used in the past, we shall send you another, more detailed questionnaire. Hence, it is important that you indicate the name and address of the person to whom the second questionnaire should be sent.

Thank you for your assistance in completing the questionnaire and returning it to us.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db
Enclosure

QUESTIONNAIRE

Return to:

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50010

Concerning the use of certain types of stop control devices at school crossing in ______________________________, the following information is requested.

	Yes	No
Are portable (roll-out) stop signs currently in use?	☐	☐
They are not currently used but were formerly used.	☐	
Are stop signs used that fold or rotate to vary the message?	☐	☐
They are not currently used but were formerly used.	☐	

If the answer to any of the above is yes, a more detailed questionnaire will be sent. To whom should it be addressed:

Name____

Position____

Address____

___________________________Zip_________________

Please return this questionnaire even if your response is No to both questions.

Questionnaire completed by:

Name (please print)_______________________________

Position____

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 16, 1977

(Initial questionnaire to county sheriffs)

The Engineering Research Institute at Iowa State University is undertaking a research study for the Iowa Department of Transportation entitled "Portable School Stop Signs and Other Non-Uniform School Stop Control Devices". As you may be aware, portable stop signs, although permitted under Iowa law to delineate school zones, do not conform with federal standards. An objective of our research is to establish the benefits, if any, of their use and to make an evaluation of whether to recommend changes in either federal requirements or state law. We need your assistance in carrying out this research responsibility.

The purpose of this inquiry is to determine whether portable (roll-out) stop signs are currently being used at school crossings in your county. We have directed a questionnaire to each incorporated community to determine their use. A further subject of our investigation is the use of other types of school signs that display a STOP message only during certain hours. This is usually effected by means of a sign that folds or is rotated to vary the message displayed to motorists. The questionnaire also requested information on use of these devices.

Our purpose in writing you is to determine the use of such devices in rural areas within your county and, in the expectation of something less than 100 percent response from incorporated communities, to make certain that we are aware of all cities in which they are currently being used. Please complete the enclosed questionnaire and return it to us in the prepaid envelope. Note that we need your response even if none of these devices are being used. Thank you for this assistance.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db
Enclosure

QUESTIONNAIRE

Return to:

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50010

Concerning the use of certain types of stop control devices at school crossings in____________________County, the following information is requested.

Are portable (roll-out) stop signs currently in use? Yes No

If yes, indicate locations.

Rural areas____

____

____

In which communities_____________________________________

____

Are stop signs that fold or rotate used? Yes No

If yes, indicate locations and describe generally.

Rural areas____

____

____

In which communities_____________________________________

____

Describe the type of sign________________________________

____

Questionnaire completed by:

Name____

Position____

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

(Initial questionnaire to states)

The Engineering Research Institute at Iowa State University is undertaking a research study for the Iowa Department of Transportation entitled "Portable School Stop Signs and Other Non-Uniform School Stop Control Devices". Portable (roll-out) stop signs are permitted under Iowa law to delineate school zones and are widely used at crossings in the state for this purpose. The conflict with the Manual on Uniform Traffic Control Devices is evident. There is also widespread use of other types of school signs that display a STOP message only during certain hours. This is usually effected by a changeable message sign that folds or is rotated to vary the message displayed to motorists. An objective of our research is to establish the benefits, if any, from the use of these devices and to make appropriate recommendations to the Iowa Department of Transportation.

The purpose of this inquiry is to determine whether similar devices which may not conform with the MUTCD are used at school crossings in your state. You are requested to indicate on the enclosed questionnaire whether these devices are currently in use in your state. A postage paid envelope is enclosed for your use in returning the questionnaire. I shall communicate further with those who respond affirmatively in order to determine limitations set forth by the state for their use, legal status, warrants, standard designs, and an evaluation of experience with these devices. You are therefore requested to indicate the person to whom a follow-up inquiry should be directed in case of an affirmative response.

Thank you for your assistance in responding to this inquiry and returning the questionnaire to us.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/pjp
Enclosure

QUESTIONNAIRE

Return to:

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50011

Concerning the use of certain types of stop control devices at school crossings in ______________________, the following information is requested.

	Yes	No
Are portable (roll-out) stop signs used?	☐	☐
Are changeable message stop signs used?	☐	☐

If yes, describe this type of sign.

____

____

____

(Any additional information on your use of these signs will be appreciated.)

If the answer to any of the above is yes, a more detailed questionnaire will be sent. To whom should it be addressed?

Name ____

Position ____

Address ____

______________________________ Zip ______________

Questionnaire Completed by:

Name (please print) ______________________________

Position ____

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 20, 1977

(To cities with questionnaire C1)

In response to an earlier inquiry, we were advised that portable (roll-out) stop signs are currently being used at school crossings in your community. The enclosed questionnaire seeks further information on the use of these devices. Your cooperation in completing and returning the questionnaire will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

July 11, 1977

(To cities with questionnaire C1)

We were informed by the Sheriff of your County that portable (roll-out) stop signs are currently used at school crossings in your community. The enclosed questionnaire seeks further information on the nature and extent of use of those devices.

This inquiry is part of a study for the Iowa Department of Transportation to evaluate the use of these signs. We are also to recommend the most appropriate course of action in view of the conflict between Iowa state law and federal standards regarding their use. Consequently, your response is important to us in our effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa.

Please use the enclosed prepaid envelope to return the questionnaire. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosure

QUESTIONNAIRE C1

Return to:

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50011

1. At how many school crossings are portable stop signs in use?

   Immediately adjacent to school (number) ______________

   Elsewhere on school routes ______________

   Total crossings ______________

2. Time of use when school is in session?

   From ________ to ________ and from ________ to ________ and from ________ to ________.

3. Who places the portable signs?

   ☐ Police
   ☐ Employee at school where located
   ☐ Other school system employee
   ☐ Other (explain) ______________

4. On what type(s) of routes are portable signs used?

	Yes	No	Typical speed limit, mph
U.S. and state highways	☐	☐	________
Other major routes	☐	☐	________
Less-traveled routes	☐	☐	________

5. Number of signs typically used per crossing?

   ☐ One ☐ Two

6. Are warning signs typically used in conjunction with a portable (roll-out) stop sign?

   ☐ Yes ☐ No

7. Are adult crossing guards normally used with any of the portable (roll-out) stop signs in your community?

   ☐ Yes ☐ No

(Please complete reverse side)

C1 Continued

8. Have problems arisen because of misuse of portable (roll-out) stop signs after school hours?

   ☐ Yes ☐ No

   If yes, explain____

9. Please express your opinion of the use of portable (roll-out) stop signs at school crossings.

   a. In general (check one)
      - ☐ I like them
      - ☐ I would like to see better devices for school crossings

   b. Regarding accident experience (check one)
      - ☐ I believe that they prevent accidents
      - ☐ I believe that they have no effect on accidents
      - ☐ I believe that they possibly increase accidents

   c. Regarding motorist observance when signs in use (check one only)
      - ☐ Most motorists stop
      - ☐ At least half of the motorists stop
      - ☐ Fewer than half of the motorists stop
      - ☐ I don't know

   Comments____

Questionnaire completed by:

Name______________________________

Position______________________________

Address______________________________

Zip

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 20, 1977

(To cities with questionnaire C2)

In response to an earlier inquiry, we were advised that portable (roll-out) stop signs, although not currently being used, were previously used at school crossings in your community. The enclosed questionnaire seeks further information on the use of these devices. Your cooperation in completing and returning the questionnaire will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

QUESTIONNAIRE C2

Return to:

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50011

1. At how many school crossings were portable stop signs in use?
   Immediately adjacent to school (number) ______________
   Elsewhere on school routes ______________
   Total crossings ______________

2. Time of use when school was in session?
   From________ to________ and from________ to________ and from ________ to________.

3. Who placed the portable signs?
   ☐ Police
   ☐ Employee at school where located
   ☐ Other school system employee
   ☐ Other (explain)______________________________

4. On what type(s) of routes were portable signs used?

	Yes	No	Typical speed limit, mph
U.S. and state highways	☐	☐	________
Other major routes	☐	☐	________
Less-traveled routes	☐	☐	________

5. Number of signs typically used per crossings?
   ☐ One ☐ Two

6. Were warning signs typically used in conjunction with a portable (roll-out) stop sign?
   ☐ Yes ☐ No

7. Were adult crossing guards normally used in conjunction with any of the portable (roll-out) stop signs in your community?
   ☐ Yes ☐ No

(Please complete reverse side)

C2 Continued

8. Did problems arise because of misuse of portable (roll-out) stop signs after school hours?

☐ Yes ☐ No

If yes, explain ____________________

____

9. Please express your opinion of the use of portable (roll-out) stop signs at school crossings.

   a. In general (check one)

      ☐ I liked them
      ☐ I found them ineffective

      Explain ____________________

      ____

   b. Regarding accident experience (check one)

      ☐ I believe that they prevented accidents
      ☐ I believe that they had no effect on accidents
      ☐ I believe that they probably increased accidents

   c. Regarding motorist observance when signs were in use (check one)

      ☐ Most motorists stopped
      ☐ At least half of the motorists stopped
      ☐ Fewer than half of the motorists stopped
      ☐ I don't know

Comments ____________________

____

____

10. Please explain why your community discontinued the use of portable (roll-out) stop signs at school crossings? ____________________

____

____

Questionnaire completed by:

Name ____________________

Position ____________________

Address ____________________

____

____________________ Zip

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 20, 1977

(To cities with questionnaire C3)

In response to an earlier inquiry, we were advised that certain non-standard stop signs are currently being used at school crossings in your community. These devices display a STOP message only during certain hours after which the sign is folded or rotated to change the message displayed to motorists. The enclosed questionnaire seeks further information on the use of these devices. Your cooperation in completing and returning the questionnaire will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

July 11, 1977

(To cities with questionnaire C3)

We were informed by the Sheriff of your County that certain non-standard stop signs are used at school crossings in your community. These devices display a STOP message only during certain hours after which the sign is folded or rotated to change the message displayed to motorists. The enclosed questionnaire seeks further information on the nature and extent of use of these devices.

This inquiry is part of a study for the Iowa Department of Transportation to evaluate the use of these signs. We are also to recommend the most appropriate course of action in view of the conflict between Iowa state law and federal standards regarding their use. Consequently, your response is important to us in our effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa.

Please use the enclosed prepaid envelope to return the questionnaire. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosure

QUESTIONNAIRE C3

Return to:

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50011

1. At how many school crossings are non-standard school stop signs in use?

   Immediately adjacent to school (number) ____________

   Elsewhere on school routes ____________

   Total crossings ____________

2. Time of use when school is in session?

   From ________ to ________ and from ________ to ________ and from ________ to ________.

3. Who changes the message on these signs?

   ☐ Police
   ☐ Employee at school where located
   ☐ Other school system employee
   ☐ Other (explain) ____________

4. On what type(s) of routes are non-standard school stop signs used?

	Yes	No	Typical speed limit, mph
U.S. and state routes	☐	☐	________
Other major routes	☐	☐	________
Less-traveled routes	☐	☐	________

5. Describe the type of sign being used (a sketch or drawing would be helpful)

   ____
   ____
   ____
   ____
   ____

(Please complete reverse side)

C3 Continued

6. Please express your opinion of the use of non-standard stop signs at school crossings.

   a. In general (check one)

      ☐ I like them

      ☐ I would like to see a better device for school crossings

   b. Regarding accident experience (check one)

      ☐ I feel that they prevent accidents

      ☐ I feel that they have no effect on accidents

      ☐ I feel that they probably increase accidents

   c. Regarding motorist observance when signs are in use (check one)

      ☐ Most motorists stop

      ☐ At least half of the motorists stop

      ☐ Fewer than half of the motorists stop

      ☐ I don't know

Comments ____

____

____

____

____

____

Questionnaire completed by:

Name ____

Position ____

Address ____

____

____

Zip

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 20, 1977

(To cities with questionnaire C4)

In response to an earlier inquiry, we were advised that certain non-standard stop signs, although not in use currently, were previously used at school crossings in your community. These devices display a STOP message only during certain hours after which the sign is folded or rotated to change the message displayed to motorists. The enclosed questionnaire seeks further information on the use of these devices. Your cooperation in completing and returning the questionnaire will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

QUESTIONNAIRE C4

Return to:

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50011

1. At how many school crossings were non-standard school stop signs in use?

   Immediately adjacent to school (number) ____________

   Elsewhere on school routes ____________

   Total crossings ____________

2. Time of use when school was in session?

   From__________ to__________ and from__________ to__________ and from __________ to__________.

3. Who changed the message on these signs?

   ☐ Police
   ☐ Employee at school where located
   ☐ Other school system employee
   ☐ Other (explain)____________________________________

4. On what type(s) of routes were non-standard school stop signs used?

	Yes	No	Typical speed limit, mph
U.S. and state highways	☐	☐	________
Other Major routes	☐	☐	________
Less-traveled routes	☐	☐	________

5. Describe the type of sign that was used (a sketch or drawing would be helpful)

____
____
____
____
____
____

(Please complete reverse side)

C4 Continued

6. Please express your opinion of the use of non-standard stop signs at school crossings.

   a. In general (check one)

      ☐ I liked them

      ☐ I found them ineffective

      Explain ______________________________

      ____

   b. Regarding accident experience (check one)

      ☐ I felt that they prevented accidents

      ☐ I felt that they had no effect on accidents

      ☐ I felt that they probably increased accidents

   c. Regarding motorist observance when signs were in use (check one)

      ☐ Most motorists stopped

      ☐ At least half of the motorists stopped

      ☐ Fewer than half of the motorists stopped

      I don't know

   Comments ______________________________

   ____

   ____

   ____

7. Please explain why your community discontinued the use of non-standard stop signs at school crossings. ______________________________

   ____

   ____

   ____

Questionnaire completed by:

Name ______________________________

Position ______________________________

Address ______________________________

____

______________________________ Zip

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 20, 1977

(To cities with questionnaire C1, C3)

In response to an earlier inquiry, we were advised that both portable (roll-out) stop signs and other signs that fold or rotate so as to display a STOP message only during certain hours are currently being used at school crossings in your community. We consequently have enclosed two questionnaires, one covering each type of device, in order to obtain further information on their use. Questionnaire C1 pertains to portable (roll-out) stops signs and Questionnaire C3 to other non-standard stop signs. Your cooperation in completing and returning both questionnaires will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

July 11, 1977

(To cities with questionnaires C1, C3)

We were informed by the Sheriff of your County that both portable (roll-out) stop signs and other non-standard signs that fold or rotate so as to display a STOP message only during certain hours are used at school crossings in your community. The enclosed questionnaires seek further information on the nature and extent of use of these devices. Note that Questionnaire C1 pertains to the portable (roll-out) stop signs and Questionnaire C3 to the other non-standard stop signs.

This inquiry is part of a study for the Iowa Department of Transportation to evaluate the use of these signs. We are also to recommend the most appropriate course of action in view of the conflict between Iowa state law and federal standards regarding their use. Consequently, your response is important to us in our effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa.

Please use the enclosed prepaid envelope to return the questionnaires. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 20, 1977

(To cities with questionnaires C1, C4)

In response to an earlier inquiry, we were advised that portable (roll-out) stop signs are currently being used and that certain non-standard stop signs were previously used at school crossings in your community. The latter devices display a STOP message only during certain hours and are folded or rotated so as to change the message displayed to motorists. We consequently have enclosed two questionnaires, one covering each type of device, in order to obtain further information on their use. Questionnaire C1 pertains to the portable (roll-out) stop signs and Questionnaire C4 to other non-standard stop signs. Your cooperation in completing and returning both questionnaires will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 21, 1977

(To cities with questionnaires C2, C3)

In response to an earlier inquiry, we were advised that portable (roll-out) stop signs were previously used and that other signs that fold or rotate so as to display a STOP message only during certain hours are currently being used at school crossings in your community. We consequently have enclosed two questionnaires, one covering each type of device, in order to obtain further information on their use. Questionnaire C2 pertains to portable (roll-out) stops signs and Questionnaire C3 to other non-standard stop signs. Your cooperation in completing and returning both questionnaires will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

June 21, 1977

(To cities with questionnaires C2, C4)

In response to an earlier inquiry, we were advised that portable (roll-out) stop signs and other non-standard stops signs, although not currently being used, have both previously been used at school crossings in your community. The latter devices display a STOP message only during certain hours and are folded or rotated to change the message displayed to motorists. We consequently have enclosed two questionnaires, one covering each type of device, in order to obtain further information on their use. Questionnaire C2 pertains to portable (roll-out) stop signs and Questionnaire C4 to other non-standard stop signs. Your cooperation in completing and returning both questionnaires will be most helpful to us in our research effort to improve the safety and convenience of pedestrian and vehicular movements in Iowa. A prepaid envelope is enclosed for your convenience. Thank you for your cooperation.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Engineering Research Institute
College of Engineering
382 Town Engineering Building
Telephone: 515-294-6778

July 11, 1977

(Follow-up questionnaire to county sheriffs)

This is a follow-up on my letter of June 16 requesting your assistance in our research on the use of portable (roll-out) stop signs or other non-uniform stop control devices at school crossings. Since sending that letter, we have received responses from over 60 percent of the cities in Iowa as well as from a majority of County Sheriffs. Consequently we are now able to focus our concern on relatively few incorporated places.

The attached questionnaire lists specific communities in your county that have not responded to our initial inquiry. Please indicate on the questionnaire whether either portable (roll-out) stop signs or other devices that rotate or fold so as to display a STOP message only at certain times are used at school crossings in these communities. An indication of the use of these devices in rural areas is also requested.

Please complete the questionnaire and return it to us in the enclosed prepaid envelope. We need your response even if none of these devices are in use. Thank you for your assistance.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering

RLC/db

Enclosure

QUESTIONNAIRE

Return to (or use the enclosed prepaid envelope):

Engineering Research Institute
382 Town Engineering Building
Iowa State University
Ames, Iowa 50011

Concerning the use of certain types of stop control devices in____________ County, please indicate the use of these devices at school crossings in the following locations:

Location	Are portable (roll-out) stop signs used? Yes	No	Are other types of stop control devices used? Yes	No
____________	☐	☐	☐ (1)	☐
____________	☐	☐	☐ (1)	☐
____________	☐	☐	☐ (1)	☐
____________	☐	☐	☐ (1)	☐
____________	☐	☐	☐ (1)	☐
____________	☐	☐	☐ (1)	☐
Rural areas	☐ (2)	☐	☐ (1)(2)	☐

(1) Please describe the type of sign______________________________

____

____

(2) Please indicate rural locations______________________________

____

Questionnaire completed by

Name______________________________

Position______________________________

APPENDIX B

SUMMARY OF QUESTIONNAIRE RESPONSES FROM CITIES IN IOWA

SUMMARY OF QUESTIONNAIRE RESPONSES FROM CITIES IN IOWA

Questionnaire C1 was directed to cities currently using portable (roll-out) stop signs (239 total responses).

- An average of 2.83 locations per community had these devices, 2.03 adjacent to a school and 0.80 elsewhere on school routes. Usage varied from an average of 9.05 per city with over 10,000 population to 1.54 locations in cities having fewer than 1,000 inhabitants.
- The frequency of usage was as follows:

Number of times/day	Number of cities	Average duration, hr
1	38	7.52
2	89	1.67
3	85	2.86
4	3	1.44
Not reported or indeterminate	24	-
Total	239	3.17

- Placement of these signs was effected by an employee at the school in 64.4 percent of the communities and less frequently by the police, an employee of the city, a student, a private citizen, an employee of a school system, or a crossing guard.
- Of the uses reported, 41.8 percent were on primary highways. Speed limits on these routes were predominantly 25 mph (53.6 percent), but varied from 15 mph to 45 mph.
- 81.2 percent of the respondents used only one portable sign per crossing.

- 51.1 percent used warning signs in advance of a stop sign.
- 14.8 percent used crossing guards (adult or school patrol). Usage of guards varied from 31.6 percent (6 of 19) in cities with over 10,000 population to 6.9 percent (7 of 102) in cities with less than 1,000 population.
- 82.4 percent of the respondents reported no problems due to misuse of portable stop signs after school hours. Most frequently mentioned as problems were vandalism or unauthorized placement.
- Opinions expressed on the questionnaires indicated that 59.6 percent of the respondents (130 of 218 who expressed an opinion) liked portable stop signs, and 40.4 percent would like to see better devices for school crossings. An additional 21 respondents did not express an opinion. The proportion desiring something better among cities responding to this question varied from 66.7 percent (12 of 18) for cities with over 10,000 population, to 16.7 percent (2 to 12) for cities with populations from 5,000 to 9,999.
- 89.3 percent of the respondents expressing an opinion (193 of 224) believed that portable signs prevented accidents, 8.0 percent believed that they had no effect on accidents, and 2.7 percent believed that they increased accidents. There were no significan differences in responses among sizes of cities responding.
- 94.1 percent (208 of 221) expressed an opinion that most motorists stopped at portable stop signs, 5.4 percent felt that at least half stopped, and one respondent (0.5 percent) believed that fewer than half stopped.

- 52 of the respondents (21.8 percent) expressed a further comment. 19 stated that they would like something better, 16 reiterated a previously expressed favorable opinion, 10 defined shortcomings, 5 stated their belief that portable signs were effective when used with a crossing guard, and 2 explained that they used the signs in conjunction with flashing lights.

Questionnaire C2 was directed to cities that discontinued use of portable (roll-out) stop signs (53 total responses). Except as pointed out below, the proportions of various responses were very similar to those received for questionnaire C1 from cities currently using portable stop signs.

- Average use of portable signs, by 50 cities responding to this question, was 4.20 signs per community; 3.40 were adjacent to a school.
- 24.0 percent used warning signs in advance of the stop signs.
- Reasons given for discontinuance of portable signs included the following (including multiple responses):
    - 10 stopped use when a school was closed.
    - 15 replaced them with another form of control, either permanent stop signs, flashing lights, or a crossing guard.
    - 6 removed them when a highway location or the location of a school bus stop changed.
    - 8 ceased to use roll-out signs because of their lack of conformity with provisions of the MUTCD.

- 9 expressed specific problems relating to their use including maintenance, vandalism, and rolling stops.
- 9 indicated rather general objections to portable stop signs.
- Use was discontinued in 1 city in response to a petition from the people.

Questionnaire C3 was directed to cities currently using other non-uniform stop control devices at school crossings (37 total responses).

- Average use of these devices was reported as 6.03 per city; 4.82 were adjacent to a school and 1.21 were elsewhere. The average total varied from 1.64 in the smallest class of city size to 16.67 per city in the largest population class.
- Frequency and duration of use were reported as follows:

Number of times/day	Number of cities	Average duration, hr
1	8	8.03
2	12	1.76
3	13	3.01
Not reported or indeterminate	4	-
Total	37	3.77

- 75.7 percent of the communities reported that an employee at a school effectuated the devices at or near that school.
- The most common use of this type of device (in 63.6 percent of the communities answering this question) was reported on less traveled routes, with only 22.9 percent reporting any use on primary highways. Speed limits on streets where these devices were used were predominantly 25 mph.

- 18 cities used signs that fold, 11 cities used signs that rotate, 2 cities used flashing lights only, and 6 cities either did not answer Question 5 or gave non-responsive answers.
- Of the respondents who expressed an opinion, 72.7 percent (24 of 33) liked the temporary devices and 27.3 percent would like to see a better device for school crossings. 2 respondents marked both answers and 2 others did not answer Question 6a.
- 33 of 34 respondents (97.1 percent) to Question 6b felt that the temporary devices serve to reduce accidents. The other respondent felt that they had no effect on accidents.
- Responses to Question 6c, excluding those who did not reply, were as follows: 32 (94.1 percent) believed that most motorists stop, and 1 each believed that at least half stop or answered "don't know."
- 18 of the respondents (48.6 percent) added additional comments. These generally reiterated or expanded upon answers previously given. 8 responses expressed misgivings about non-uniform devices and mentioned less than complete obedience (4 responses), lack of visibility (3 responses), or signs being turned by the wind or by children (1 response).

Questionnaire C4 was directed to cities that have discontinued use of other non-uniform school stop control devices (10 total responses). Because of the small sample size, no general analysis of these responses will be reported. However, the following opinions are of particular interest:

- More than half of the respondents (5 of 9) who answered Question 6a found the devices ineffective.
- 4 respondents (of 9) answering Question 6b felt that these devices had no effect on accidents, 4 felt that they prevented accidents, and one felt that they probably increased accidents.
- Comments were received from 7 respondents. Two of these installations were replaced with full-time control, signals in one city and a four-way stop in the other. One respondent commented that the signs were illegal. Other comments reiterated or expanded upon answers given previously.

APPENDIX C

FIELD SURVEY LOCATIONS

Table C-1. Field survey locations.

Number	City (Iowa DOT District)	Street location	1970 population	Type of device (1)	Type of location (2)
1- 1	Adel (4)	U.S. 6-S. 14th St.	2,419	1	X
2- 1	Ames	Ontario Rd.-Arizona Ave.	39,505	1	X
2- 2	(1)	20th St.-Northwestern Ave.		1	X
3- 1	Armstrong (2)	Ia. 15-4th Ave.	1,061	2	X
4- 1	Audubon (4)	South St.-Tracy St.	2,907	2	X
5- 1	Bloomfield (5)	W. Jefferson St.-Columbia St.	2,718	1	X
6- 1	Clinton	N. 5th Ave.-N. 4th St.	34,719	2	X1
6- 2	(6)	2nd Ave. Rd.-Thorwaldsen Pl.		2	T
7- 1	Council Bluffs	C Ave.-N. 32nd St.	60,348	1	X
7- 2	(4)	6th Ave.-S. 34th St.		1	XU
8- 1	Donnelson (5)	U.S. 218-Orchard St.	798	1	X
9- 1	Dubuque	25th St.-Jackson	62,309	1	X
9- 2	(6)	E. 13th St.-White		1	X1
10- 1	Farragut (4)	Co. M16-Washington St.	521	1	X
11- 1	Garner (2)	8th St.-Bush Ave.	2,217	2	X
12- 1	Greenfield	Ia. 92-SW. 2nd St.	2,212	1	X
12- 2	(4)	NW. Elm St.-NW. 2nd St.		2	T
13- 1	Grinnell	8th Ave.-Reed St.	8,402	1	X
13- 2	(1)	Washington Ave.-Broad St.		1	X
14- 1	Hawarden (3)	13th St.-H Ave.	2,789	2	T
15- 1	Hinton (3)	U.S. 75-Main St.	488	1	X
16- 1	Indianola	S. 1st-E. 3rd Ave.	8,976	2	XU
16- 2	(5)	N. Buxton St.-Clinton Ave.		2	X1
16- 3		N. 9th St.		2	M
17- 1	Lake City (3)	Woodlawn St.-North St.	1,910	1	X
18- 1	Lenox	N. Maple St.-W. Michigan St.	1,215	2	X
18- 2	(4)	N. Maple St.-W. Ohio St.		2	X
19- 1	Malvern (4)	Co. L63-1st St.	1,158	1	T
20- 1	Mason City	12th St. NW.-N. Madison Ave.	31,839	1	T
20- 2	(2)	9th St. NW.-N. Monroe Ave.		1	X
21- 1	Maxwell (1)	5th St.-Maxwell St.	758	1	X
22- 1	Mount Pleasant (5)	W. Henry St.-N. White St.	7,007	2	X

Table C-1. (Continued.)

Number	City (Iowa DOT District)	Street location	1970 population	Type of device (1)	Type of location (2)
23- 1	Newton (1)	N. 19th St. E.	15,619	2	M
24- 1	Norwalk (5)	Main St.-School Ave.	1,745	2	X
24- 2		Cherry St.-North Ave.		2	X
24- 3		Ia. 28-Main St.		1	X
25- 1	Orange City (3)	2nd St. SW.-Delaware Ave. SW.	3,572	2	X
26- 1	Shellsburg (6)	Cottage St.	740	2	M
27- 1	Sibley (3)	8th St.-7th Ave.	2,749	2	X
27- 2		7th St.-6th Ave.		2	X
28- 1	Solon (6)	Ia. 382-N. Chabal	837	1	X
28- 2		Ia. 1-E. 1st.		1	X
29- 1	Spencer (3)	4th Ave. W.-W. 3rd St.	10,278	1	X
29- 2		4th Ave. W.-W. 4th St.		1	X
29- 3		4th Ave. E.-E. 11th St.		1	X
29- 4		5th Ave. E.-E. 16th St.		1	XU
30- 1	Thornton (2)	Ia. 107-5th St. N.	410	2	X
31- 1	Vinton (6)	4th Ave.-5th St. E.	4,845	1	XU
31- 2		D Ave.-8th St. W.		1	X
32- 1	Waterloo SMSA, incl. Cedar Falls (2)	Easton Ave.-Oregon St.	75,533	2	X
32- 2		7th St.-Washington St.	29,597	2	X1
32- 3		W. 4th St.-Angie Dr.		2	X
33- 1	Webster City (1)	Des Moines St.-Odell St.	8,488	2	X
33- 2		Walnut St.		2	M

(1) Type of device: 1 - portable (roll-out) stop sign
2 - other non-uniform school stop control device

(2) Type of location: X - four-way intersection, two-way traffic
X1 - four-way intersection, one-way traffic on major street
XU - four-way intersection normally with no stop control
T - tee intersection
M - mid-block crossing

APPENDIX D

FIELD SURVEY DATA SHEET

SCHOOL STOP PROJECT

SURVEY DATA SHEET

Date:______________ Town:______________ Population:__________

Location:______________________________

____

Nearby School: K. E.S. J.H. S.H.

Time:______________________________

Weather Condition: Clear, Cloudy, Rain, Snow, Sleet, Fog, Mist

Surface Type:______________________

Surface Condition: Dry, Wet, Snow, Ice, Mud

Marking Condition: Good, Fair, Poor

Control Type: Rollout Stop Sign, Crossing Guard, Other__________

____

Time of Use:______________________

Road Classification:______________

Speed Limit: Posted, None__________

No. of Lanes:______________

______(major street):__________

______(minor street):__________

Approach Visibility:__________

Parking Restrictions:__________

____

____

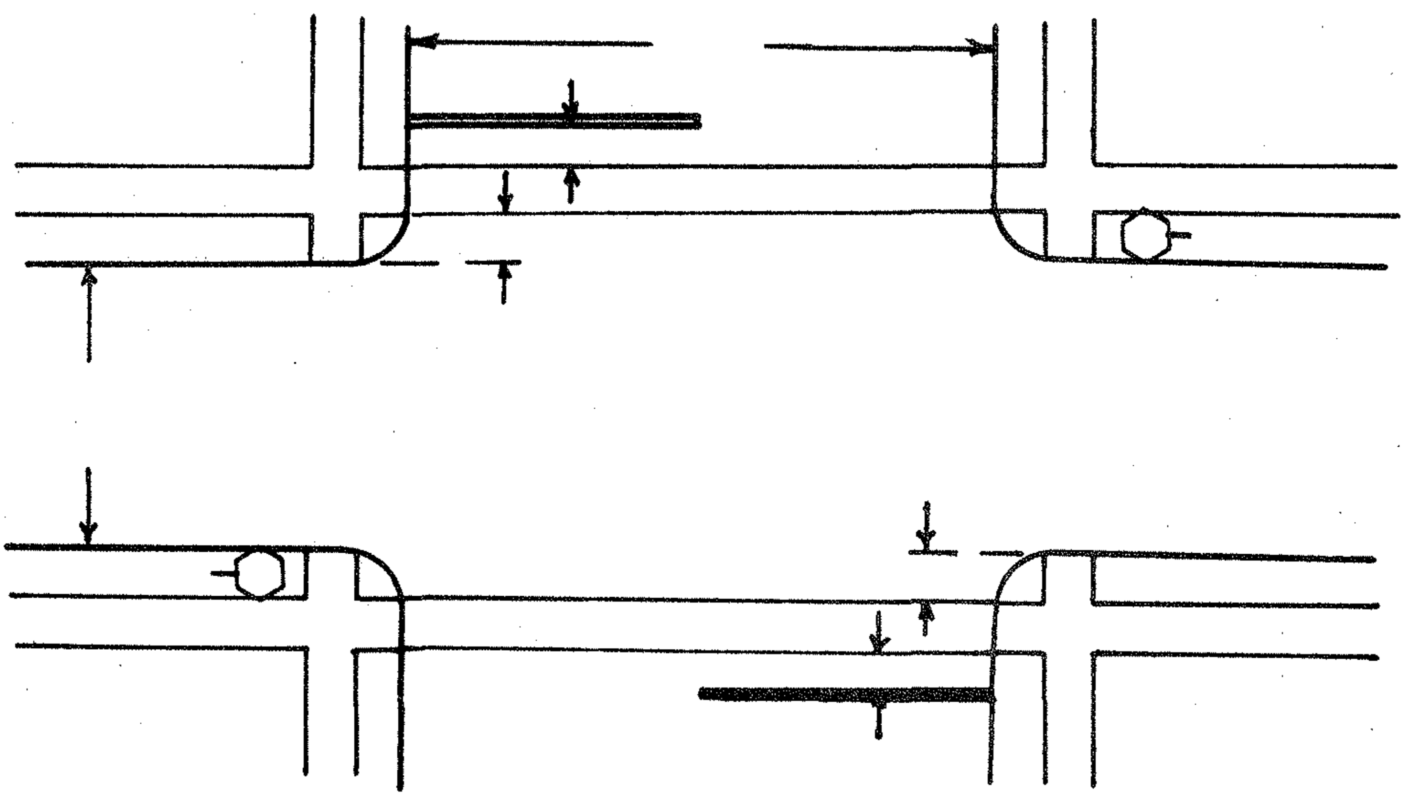
Width of Stop Line:__________

Type of Crosswalk:

Comments:______________________

____

____



APPENDIX E

CORRELATION MATRIX FOR REGRESSION VARIABLES

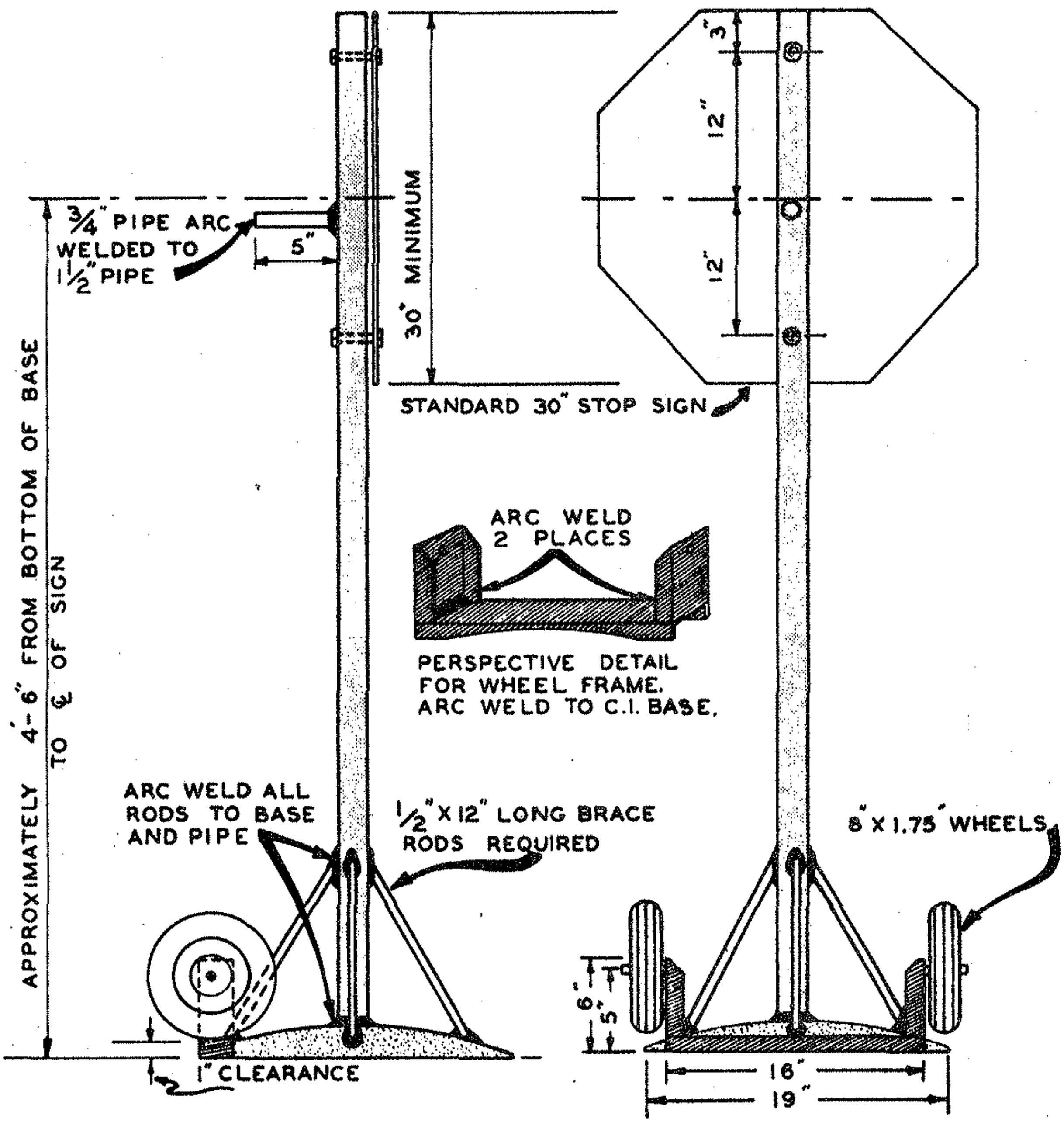
Table E-1. Simple correlation matrix for regression variables.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
Y	0.583	0.504	0.109	0.199	0.329	-0.024	0.140	0.166	0.088	-0.234	0.215	0.064	0.141	0.181	(Not included)
Y_1	0.130	-0.014	0.206	-0.051	-0.288	0.155	0.162	0.118	-0.031	-0.037	0.398	-0.061	-0.204	-0.123	-0.761
Y_2	0.366	0.352	0.592	0.161	0.144	0.030	0.051	-0.074	0.252	0.096	0.283	0.029	-0.107	0.261	0.040
X_1		0.318	0.221	0.347	0.188	-0.148	-0.113	-0.032	0.034	0.038	0.114	-0.158	0.065	0.241	0.039
X_2			0.093	0.222	0.234	-0.105	0.218	-0.045	-0.015	-0.223	0.128	-0.023	0.406	0.151	0.242
X_3				0.018	0.098	0.230	0.156	0.059	0.300	0.358	0.359	0.077	-0.106	0.313	-0.100
X_4					0.153	-0.419	0.020	0.076	0.010	-0.077	0.174	0.241	0.305	0.071	0.105
X_5						-0.087	0.062	0.339	0.357	0.023	0.119	0.133	0.238	0.251	0.439
X_6							0.247	0.014	0.109	0.096	0.254	-0.019	-0.087	0.302	-0.213
X_7								0.087	0.294	0.187	0.303	0.263	0.137	0.259	-0.093
X_8									-0.053	0.088	-0.059	0.136	-0.023	-0.155	-0.090
X_9										-0.038	0.245	0.160	-0.029	0.308	0.177
X_{10}											-0.010	-0.203	-0.259	0.155	-0.026
X_{11}												0.078	0.006	0.444	-0.113
X_{12}													0.179	0.020	0.121
X_{13}														-0.009	0.250
X_{14}															0.238

APPENDIX F

TYPICAL STANDARD FOR PORTABLE SCHOOL CROSSING STOP SIGN

TYPICAL STANDARD FOR PORTABLE SCHOOL CROSSING STOP SIGN



Approximate Weight—Cast Iron Base—40 Pounds.
Wheel Frame to be Constructed of Three Pieces of 1"x2" Channel Iron.
The 16" Member cut to fit Contour of Base.
Material Required:
1-30" Standard Stop Sign: 1 Pc. 3/4" Pipe 5" Long;
1 Pc. 1 1/2" Pipe 5'4" Long; 2 3/8"x1/2" Long Bolts with Nuts;
4 Pcs. 1/2"x12" Long Rods; 1 Pc. 1"x2"x1'4" Long and 2 Pcs. 1"x2"x5" Channel Iron;
2-8"x1.75" Wheels with Axles to Suit; 1-Cast Iron Base 1'7" Diameter.
Scale: 3/32 Inch = 1 Inch

SEPTEMBER 7, 1973